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The Welsh Engineers' and Founders' Association
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Contents

	PAGE
American Steel Castings	291
Notes from the Branches	292
Unemployed Metals	292
Third Report of the Oxygen Sub-Committee ...	293
Institute of British Foundrymen	296
U.S. Aluminium Industry	296
Plant for the Melting of Aluminium and its Alloys	297
Chromium-Molybdenum Cast Iron for Drawing and Forming Dies	299
War Damage Insurance	299
Steel Castings in the Electrical Industry	300
Automatic Control of Arc Furnaces	300
Core-Drying Shells	300
Vitreous Enamelling Section:— Observations on Cast-Iron Enamelling	301
An Open-Air Art Gallery	304
High-Duty Cast Irons for General Engineering Purposes	304
The Week's News in Brief	306
Trade Talk	306
Personal	306
Obituary	306
Reports and Dividends	306
Contract Open	306
New Companies	306
Applications for Trade Marks	306
Pig-iron Merchants' Association	306
Raw Material Markets	308
Patent Specifications Accepted	308

American Steel Castings

We are probably wrong, but we have always imagined that the professional engineer desired that his data should be prescribed to him in potted form as exemplified by Molesworth. American opinion, as is well illustrated by the issue of "Steel Castings Handbook,"* tends in the direction of providing statistical information for engineers in the form of a readable, well-illustrated and essentially modern textbook. By so doing, they have made their production equally as valuable to the steel founder as to the engineer. This has come about through the co-operation which has been accorded by all the firms forming the American steel foundry industry. Obviously not one of them possessed the whole of data collected within its 500 odd pages. It was an excellent notion to devote the earlier pages to giving something of the history of the steel foundry industry. Such a feature to mean anything has to be well done, and to appeal to a catholicity of tastes. To us, the story of the discovery of the green sand moulding process as applied to steel made the greatest appeal. To others, the illustrated description of the world's largest steel casting, a monster weighing in the finished state just over 200 tons, would be the *pièce de résistance*. Yet again others would find major interest in the consumption of steel castings by the various industries. Shipbuilding, marine engineering, plus Government buying, absorbed only 1.2 per cent. Unfortunately a similar analysis of European production over the period 1929 to 1935 would disclose quite a different picture. What is shown, however, is the vast war-potential possessed by this section of the American industry.

The review of the various melting processes used is quite divorced of bias, although it is admitted that the baby Bessemer has been a *rara avis* in American practice. Even the age-old controversy as to whether Henry Bessemer or William Kelly discovered the pneumatic process of making is closed by the compromise of "independent discovery." The engineer gets his turn on reaching Chapter IV, for from there onwards the data he uses in his daily work are presented in orderly fashion. His close attention should be called to Chapter XIII, wherein design is specifically dealt with. This part is so important that the authorities on this side should take steps to see that information of a similar character gets in the hands of those responsible for the designing of steel castings. The Reports of the steel castings committees disclose that much data are available, and need but assembly for presentation to the designer. There is much of interest to the steel foundry in the section devoted to the commercial applications of steel castings, for here is given a cross section of the industrial uses, which do not run on parallel lines with United Kingdom production. The field is distinctly wider, and is by no means restricted to railways, mining, shipbuilding and armaments as is, generally speaking, the case here.

It is obvious from a perusal of the two hundred and twenty pages devoted to cast alloy steels that American practice is very advanced. Much of the data disclosed is quite new, having been recently compiled from industrial sources. We expected to find in the chapter, "Engineering Properties," which follows those dealing with special steels, a summary of the matter previously disclosed, but instead new material covering such subjects as damping capacities, machining rates and corrosion fatigue well round off the more commonplace aspects. After all, tensile strengths and related properties are covered by the normal acceptance to which attention is drawn later. We, like quite a number of American nationals, are not too enamoured of their standardised system of pattern colours, preferring the later ones prepared by the United Kingdom authorities. This is no criticism of the book, as the standard in question is nationally accepted.

It was particularly pleasing for us to find that the centigrade scale is given more prominence than customary, whilst the word "draw" is discouraged in favour of tempering. The only small fault which appears is that the references to numbers in one chapter have been omitted. The one outstanding feature of the book is that by description, and especially by illustration, it surely must have convinced the engineer that the American steel foundry industry is splendidly equipped, both physically and mentally, to meet his most exacting requirements. This type of information cannot be presented in the pocket book type of publication carrying the data used by engineers. We congratulate the Steel Founders' Society of America on their achievement in publishing this book, and especially in the co-operation which made it possible.

* Published by the Steel Founders' Society of America, Cleveland, Ohio.

Notes from the Branches

East Anglian Section.—A meeting was held in Ipswich Central Library on April 19, with Mr. H. H. Shepherd presiding. Mr. J. King read a Paper on "Some Factors Influencing the Production of Sound Castings in High Duty Iron." A lengthy discussion followed its presentation. It was announced that the next meeting would be held on May 17 at 3.30 p.m., when Mr. C. H. Kain would read a Paper on the "Production of Steel Castings."

East Midlands Annual Meeting.—In the absence of Mr. S. E. Dawson (Branch-President), who is recovering from an illness, Mr. S. H. Russell presided over the Annual Meeting, which was held on March 29 in Derby. Mr. W. B. Lake (President of the Institute), together with Mr. T. Makemson (General Secretary), Mr. J. Bolton (Assistant Secretary), and Mr. Gardom (Chairman of the Technical Committee) were present.

The following branch officers were elected for the 1941/2 session:—

As *Branch-President:* Mr. H. J. Beck; *Senior Vice-President:* Mr. S. E. Dawson; *Junior Vice-President:* Mr. G. L. Harbach, and *Hon. Secretary:* Mr. S. A. Horton.

Members of the Branch Council: Mr. W. H. Smith, Mr. H. L. Sanders, Mr. H. Roxburgh, and Mr. H. P. Radford.

Delegates to General Council: Mr. A. E. Peace and Mr. G. L. Harbach.

Technical Committee: Mr. A. E. Peace and Mr. P. A. Russell.

At the conclusion of the meeting Mr. W. B. Lake presented the "Oliver Stubbs" Medal to Mr. P. A. Russell, who received it on behalf of Mr. A. E. Peace, who was indisposed.

Before presenting the award Mr. Lake expressed his pleasure at the continued success of the East Midlands Branch as reported at the Annual Meeting; he outlined the work Mr. Peace had carried out in the interest of the Institute as a whole, and his work in connection with the Technical Committee attached to the Institute, particularly stressing his recognised ability as an authority on the production of malleable iron, stating he was no doubt one of the leading authorities on the subject in Europe.

Mr. Russell, in his reply, said as a past recipient of the "Oliver Stubbs" Medal he knew how disappointed Mr. Peace would be not to have been able to receive this award personally. He had worked with Mr. Peace on the various Technical Committees and knew how much he appreciated being awarded this Medal. He could endorse all Mr. Lake had said regarding Mr. Peace, and on his behalf he would thank Mr. Lake for coming to Derby to make this presentation.

At the conclusion of the Annual Meeting the members took tea, and following this the Short Paper Competition was held.

Wales, Monmouth and West of England Branch.—At the Annual General Meeting, held at Cardiff on April 5, the following officers were elected to serve during the forthcoming session:—

Branch President: Mr. J. F. Gist, The Paddocks, Frenchay, Bristol.

Senior Vice-President: Mr. H. J. V. Williams, Globe Foundry, Cardiff.

Junior Vice-President: Mr. E. J. Kelly, Glascoed, Pontypridd.

Hon Secretary: Mr. J. J. McClelland, Newport.

Assistant Hon. Secretary: Mr. A. S. Wall, Cardiff.

Delegates to the General Council: Mr. A. Hares and Mr. W. Williams.

Technical Committee: Mr. R. J. Richardson and Mr. H. J. V. Williams.

Mr. McClelland tendered his resignation as Hon. Secretary, to take effect as from the end of the present year.

It was reported that, as a result of the tools offered by Mr. McClelland through his daughter (Councillor Mrs. Ethel Rawden) to members of the Institute, the sum of £21 3s. 6d. had been raised for the funds of the National Lifeboat Institution and the Airmen's Comforts Fund. The tools were secured by Thomas Richards & Sons, Limited, Bristol.

Mrs. Rawden would like to thank all those who so ably supported this effort, and to add how much she appreciated the many kind letters she received.

Institute Elects New Members

At a Council Meeting of the Institute of British Foundrymen, held at the Midland Hotel, Manchester, on April 19, the following were elected to the various grades of membership:—

As Subscribing Firm

Pierce & Company, Limited, Wexford, Eire (representative, C. W. Clarke).

As Members

G. B. Brand, works manager, R. W. Crosthwaite, Limited, Thornaby; W. W. Edwards, smelting superintendent, Langley Alloys, Limited; N. Moore, assistant to works manager, Herbert Morris, Limited; G. Grainger, works engineer, Crabtree & Company, Limited; E. Hunter, director, J. Harper (Meehanite), Limited, Willenhall; E. M. Lloyd, British Insulated Cables, Limited, Sheffield

As Associate Members

A. K. J. Bean, patternmaker, Davey Paxman (Colchester), Limited; A. C. Brearley, metallurgist, David Brown & Sons (Hudd.), Limited; A. H. Binning, patternmaker, Rolls-Royce, Limited, Scotland; M. Draper, foreman coremaker, Rolls-Royce, Limited, Scotland; A. H. Ell, moulder, Davey Paxman (Colchester), Limited; J. A. F. Jarvis, foundry inspector, Rolls-Royce, Limited, Scotland; R. Leeks, metallurgical chemist, Davey Paxman (Colchester), Limited; A. McLean, metallurgist, Rolls-Royce, Limited, Scotland; K. Patefield, assistant chemist, Eng. Electric Company, Limited; W. Rodger, general foreman, Eng. Electric Company, Limited; J. R. Simpson, foundry foreman, J. Stone & Company, Limited, Deptford, S.E.; G. S. Strachan, moulder, Rolls-Royce, Limited, Scotland; F. Telfer, assistant chemist, E. Hind (Southbank), Limited; J. Walker, assistant metallurgical chemist; R. L. Wylie, foreman coremaker, Rolls-Royce, Limited, Scotland.

H. R. Bond, foreman, Low Moor Alloy Steels, Limited, Bradford; H. Dewhirst, moulder, Smith & Paget, Keighley; G. H. Scarfe, foreman coremaker, D. Brown & Sons (Hudd.), Limited, Penistone; J. Simpson, assistant foundry manager, Rochdale Aluminium & Bronze Foundry Company, Limited, Lancashire; W. S. Spenceley, foundry foreman, Thos. Robinson & Sons, Limited, Rochdale; C. D. Tuck, moulder; J. T. Wilkinson, foundry foreman, Crane Foundry Company, Limited, Wolverhampton; R. D. Cheyne, assistant foundry foreman, Davey Paxman (Colchester), Limited.

(*Continued from next column.*)

the foundry, stock upon which the cost of fabricating has been expended will be written down to scrap value, but with war being waged on sea and land can the country afford to allow that fact to stand in the way of a one hundred per cent. employment of all its resources? Adequate stocks there must be, and there is no sense in going to extremes, but unemployed metals must be found work without delay.

Unemployed Metals

BY "ONLOOKER."

The question of the turnround in shipping has of late been front page news, for the Government has made very plain the importance of saving every hour between the arrival date and the time of departure of vessels operating on the Atlantic route. A ship laid up in port is not fulfilling its function any more than is an idle machine, and this principle of keeping things on the move may be applied right through the whole range of the national effort. There is certainly a lesson in this for the metal manufacturer, who, while he may not be offending by having any part of his plant standing, can put a drag on the wheels of progress towards ultimate victory if he claims for use in the course of his production programme too big a share of the country's stocks. The larger the output the greater will be the tonnage on hand in the form of raw material, process and finished stocks, but even so there is an upper limit beyond which the total stocks should not be allowed to go. In the metal trade there are so many different types of manufacture, and circumstances vary so much that it is impossible to lay down any hard and fast rules, but it should be possible for every concern to decide how often in the course of a year its stock should be turned over. If, for example, a fair and reasonable number is once a month taken on the basis of an annual production of 12,000 tons, the stock on hand at any given time should not exceed 1,000 tons.

This may be criticised by the practical man as a counsel of perfection based on theory, but unless some stand is taken and every effort made to keep down to a specified limit it will be found that the tonnage on hand creeps up bit by bit until the stock, instead of being turned over twelve times in the year, is moving sluggishly at the rate of perhaps six. It is, of course, only too easy to drift into a position where, say, three-quarters of the stock is "alive" and one-quarter "dead," *i.e.*, laid on one side and doing nothing. To this condition of affairs a number of factors may contribute, among them being unusable scrap and residuals created during the processes of manufacture, overestimation of what constitutes reasonable needs for manufacturing purposes, the fabrication of articles too far in advance of their delivery date, the retention of obsolete or faulty products, etc. As already mentioned, it is fatally easy to fall into slack ways, and eternal vigilance is the price that has to be paid for avoiding these traps set for the unwary. Quite apart from the fact that in the national interest it is wrong to have metals standing idle, there is the question of capital locked up, and this in itself should act as a deterrent to the manufacturer, who is after all also a business man. Book records of the stock position will, of course, be kept, but this is not sufficient alone, and it is important that by means of actual inspection the state of affairs should be ascertained. It is a good plan, therefore, to arrange for at least a weekly look over of everything that is going through the plant so that first hand knowledge can be secured of what is on hand and how things are developing.

There is always a temptation to hoard, and just as in our home stuff tends to collect in cellar and garret, so in the factory in these days a guard must be set against the danger of an accumulation of material, usually in a finished condition, which is deemed to be too good for the melting pot. Some day, somehow, this tonnage may come in useful for one purpose or another, but in the meanwhile there is no gainsaying the fact that such stock is not pulling its weight. True, if this metal is returned to

(*Continued at foot of previous column.*)

Third Report of the Oxygen Sub-Committee

The Sub-Committee referred to in the title forms part of the Committee on the Heterogeneity of Steel Ingots, which in turn is a Joint Committee of the Iron and Steel Institute and the British Iron and Steel Federation. The Report is for submission to the Spring Meeting of the former body. The Report is of particular significance to grey iron metallurgists, for, simultaneously, the analytical methods as developed for steel are being studied as to any modifications requisite for application to pig and cast-iron. Early co-operation of this character is most valuable, as the danger of misapplication is initially prevented. We propose dealing with the Report by reproducing the general summary made by the chairman, Dr. T. Swinden; two contributions by Mr. E. Taylor-Austin and a survey of the subject by Mr. J. G. Pearce, the director of the B.C.I.R.A.

GENERAL SUMMARY

BY T. SWINDEN, D.MET., CHAIRMAN OF THE OXYGEN SUB-COMMITTEE.

The work of the members since the Second Report was published has consisted mainly of a more detailed study of existing methods, and this Report is intended to present a concise statement concerning their possibilities and also their limitations as we see them to-day.

In Section II, Part A, Mr. Sloman describes the developments in vacuum fusion equipment and restates the view that this represents our accepted method for the accurate determination of total oxygen. The importance of recognising the presence of "surface oxidation" is emphasised, it being shown that this may account for as much as 0.004 to 0.006 per cent. of oxygen on pure iron. Nitrogen results obtained by the vacuum fusion method have provided some interesting new data when studied in conjunction with those obtained by chemical methods, whereby some indication is given of the form of existence of the nitrogen in the steel. The hydrogen content of steel is being regarded with increasing interest, and determination by vacuum heating (as distinct from vacuum fusion) is being extended.

In Section II, Part C, Dr. Newell summarises briefly his further data on this subject, following the useful Paper which he contributed to the Iron and Steel Institute last year.

A significant though short section of Mr. Sloman's Paper refers to the solubility of oxygen in high-purity iron. More will be said on this subject later, but, meantime, taking advantage of the availability of appropriate samples, it is indicated that the cold solubility of oxygen in pure iron lies between 0.006 and 0.003 per cent.

The position of the fractional vacuum fusion method is fairly stated, and this subject is further elaborated by Dr. Swinden, Mr. Stevenson and Mr. Speight in Section II, Part B, in which further typical data by this method are given and are compared with results obtained by the alcoholic iodine and chlorine methods. The fractional vacuum fusion method has been particularly successful in the examination of unkilled steels of the rimming type, where it is suggested that the oxygen is present essentially as basic oxides.

As an alternative method to vacuum fusion for the determination of total oxygen alone, attention is directed to the aluminium reduction method introduced by Mr. Gray and Mr. Sanders. In Section III, Part A, these authors detail the improvements introduced in the method since it was originally described, notably whereby the atmosphere of hydrogen is dispensed with and the determination carried out under reduced pressure. Results are given indicating excellent agreement with the vacuum fusion method when applied to carbon steels, and check tests on added compounds containing oxygen show excellent recovery. A further study of the method on a wide variety of materials is being undertaken. This method has been in regular use for some time in the Central Research Department of The United Steel Companies, Limited, and in Section III, Part B, Mr. Stevenson and Mr. Speight contribute a note describing their equipment and their experience on a series of steels which confirms very good agreement with the vacuum fusion method.

Further work on the aluminium reduction method is dealt with in Section III, Part C, where Mr. Taylor-Austin describes a modified method applied to the determination of total oxygen in pig-iron. The high silicon content necessitates a modification of the original procedure as described, and evidence is submitted that this method can be satisfactorily applied to pig-iron generally, provided that a suitable sample can be obtained.

Turning now to the "residue" methods, wherein the non-metallic inclusions are separated chemically from the iron and are submitted to chemical analysis, leading in turn to a calculated content of oxygen, the necessity for further work on all these methods has been stressed in earlier Reports, and it is gratifying to be able to state that definite progress has been made in elucidating some of the earlier difficulties and discrepancies.

In Section IV, Part A, Mr. Colbeck, Mr. Craven and Mr. Murray describe their further work on the chlorine method. The latest type of equipment and procedure is carefully explained as well as an improved technique in the analysis of the residue. In Section IV, Part B, the same authors show the satisfactory application of the method to a wide variety of steels. Good agreement is forthcoming with the vacuum fusion method when testing fully killed steel. In the case of rimming steel, lower results are obtained by the chlorine method and explanations are submitted for these. In their earlier work the authors showed that the chlorine method was very promising for certain alloy steels which contained elements known to interfere seriously with the iodine method. and this Part refers to the further work which is being pursued in the application of the chlorine method to alloy steels.

In Section V, Part A, Mr. Rooney has summarised concisely the present position of the alcoholic iodine method for which he has been so largely responsible. The Part covers the work both at the National Physical Laboratory and in the collaborating laboratories. The method as now practised and herein described includes the various modifications introduced since the last Report and can now be regarded as proved and accepted for the accurate determination of the oxide-containing inclusions in low and medium straight carbon steels. The interference either proved or anticipated from elements forming stable carbides or insoluble iodides is recognised and is being made the subject of further study. As Mr. Rooney points out, it is not unusual for an accepted method to be modified to suit different types of material, and certain modifications are proposed for the application of the alcoholic iodine method to rimming steel, to which further reference is made in Section IX.

Incidentally, note is made of the successful use of alcoholic iodine solution for stripping oxide films on iron. The work since the last Report has naturally been directed mainly towards overcoming the limitations of the method, and this work has given rise to some interesting thoughts on the form of existence of certain elements in the steel, *e.g.*, aluminium and phosphorus. Sheffield University has done considerable research on the interference by carbon and has indicated the limits beyond which carbon interferes with the accuracy of results. Phosphorus has also had considerable attention, and this has led to the necessity for thoroughly drying the alcohol.

In Section V, Part B, Mr. Stevenson and Mr. Speight describe a simplification of the alcoholic iodine method, which nevertheless fulfils all the essentials and appears to produce results of sufficient accuracy for all practical purposes, subject, of course, to the limitations of the alcoholic iodine method previously referred to. The British Cast Iron Research Association has collaborated in investigating particularly the use of the aqueous method, and in Section VI, Part A, Mr. Taylor-Austin states a revised aqueous iodine method, surveying its possibilities and limitations with particular reference to the determination of oxide inclusions in pig-iron. In Section VI, Part B, Mr. Pearce presents a general review of the present position of the determination of oxide inclusions in pig-iron and cast iron.

The hydrogen reduction method (one of the earliest ever proposed for determining oxygen in steel) has been the subject of intermittent attention for many years. Interest has been renewed in the possibility of accurately determining the more readily reducible oxides, *e.g.*, iron oxide and manganese oxide, and in Section VII Mr. Stevenson briefly states the result of a considerable amount of work which, unfortunately up to the present, has not led to a satisfactory adaptation of this method. The work, however, is proceeding.

The technique of the analysis of residues is obviously important, and was dealt with at considerable length jointly by the members of the Chemists' Panel in the last Report. In Section VIII, Mr. Speight suggests some further improvements in the direction of the almost complete adoption of colorimetric methods.

In Section V, Part A, Mr. Rooney referred at length to rimming steel, which, as then stated, led him to suggest some modification of the alcoholic iodine method when examining steel of that type. In Section IX, Part A, Dr. Swinden and Mr. Stevenson describe work on a billet of rimming steel examined by the chlorine, alcoholic iodine and vacuum fusion (both total and fractional) methods. These results confirm the view that the residue methods tend to give low results, which, it is suggested, are due to the attack of the halogen reagent on uncombined iron and manganese oxides. It would appear that the fractional extraction method, as previously mentioned, is well suited for the fractional determination of oxygen in this type of steel.

Finally, in Section IX, Part B, Dr. Maddocks presents a short note, which in itself does not reflect the large amount of work which this entailed, summarising briefly the results of an examination of a series of carbon steels by the alcoholic iodine method. As intimated in other sections, this work again brings out interesting points concerning the constitution of steel, with particular reference to the form of existence, in this case, of the phosphorus.

D

RECENT DEVELOPMENTS IN THE DETERMINATION OF OXIDE INCLUSIONS IN PIG-IRON BY THE MODIFIED AQUEOUS IODINE METHOD

By E. TAYLOR-AUSTIN, F.I.C. (BRITISH CAST IRON RESEARCH ASSOCIATION, BIRMINGHAM).

In a Paper entitled "The Determination of Non-Metallic Inclusions in Pig and Cast Iron by a Modified Aqueous Iodine Method,"[1] the author described a procedure upon which it was hoped to build a reliable method for the determination of oxide inclusions in pig and cast iron. A number of problems were, however, outstanding at the time of publication of the original investigation; these have now been explained, and certain modifications have been made to increase the range of application of the method to cover all types of pig-iron other than alloy varieties. The following procedure has been successfully applied to a series of more than forty typical pig-irons, and a selection of the results obtained is compared with those by other methods in Table I.

TABLE I.—*Inclusions in Pig Iron Determined by Various Methods.*

No.	Type of iron.	Residue Analysis (as percentage of Metal) by modified aqueous iodine method.					Total oxygen. Per cent.		
		Total Oxides (SiO_2+ FeO+ Al_2O_3+ MnO).	SiO_2.	FeO.	MnO.	Al_2O_3.	Calc. from residue analysis.	By aluminium reduction.	By vacuum fusion.
13	Armco iron	0.350	0.013	0.279	0.018	0.040	0.086	0.085	—
14	Swedish iron ..	0.054	0.009	0.037	Nil	0.008	0.017	0.018	—
16	Pig irons ..	0.028	0.008	0.010	0.002	0.008	0.015	—	0.019
19		0.028	0.008	0.014	0.001	0.005	0.010	0.011	0.011
31		0.026	0.006	0.014	Nil	0.006	0.009	0.006	0.005
21		0.029	0.005	0.015	0.001	0.008	0.010	0.007	0.008
107		0.017	0.005	0.009	Nil	0.003	0.0063	0.0050	—
101		0.019	0.003	0.014	Nil	0.002	0.0053	0.0047	—
18		0.039	0.020	0.014	0.001	0.004	0.016	0.015	—
73		0.043	0.009	0.031	Nil	0.003	0.013	0.018	—
25		0.025	0.008	0.012	0.001	0.004	0.0091	0.0084	—
86		0.023	0.007	0.012	0.001	0.003	0.0084	0.010	—
111		0.046	0.020	0.023	0.001	0.002	0.021	0.019	—
84		0.021	0.005	0.013	Nil	0.003	0.0074	0.0077	—
85		0.038	0.011	0.023	Nil	0.004	0.013	0.013	—
55		0.040	0.010	0.024	0.001	0.006	0.013	0.011	—
23		0.046	0.012	0.025	0.001	0.008	0.016	0.017	—
103		0.032	0.011	0.017	0.002	0.002	0.011	0.012	—
38		0.031	0.010	0.017	Nil	0.004	0.011	0.013	—
79		0.021	0.005	0.010	Nil	0.006	0.0077	0.0071	—

Revised Aqueous Iodine Method

Reagents

Iodine/Potassium-Iodide Solution.—Dissolve 30 g. of pure resublimed iodine and 30 g. of potassium iodide in a minimum quantity of water. When solution is complete, filter and dilute to 120 ml. This solution is sufficient to treat 5 g. of iron.

Sodium Carbonate-Citrate Solution.—Dissolve 6 g. of anhydrous sodium carbonate and 12 g. of sodium citrate in 120 ml. of water.

Ammonium Citrate Solution.—Dissolve 10 g. of ammonium citrate in 100 ml. of water.

Peroxide-Citrate Solution.—To 170 ml. of 10 per cent. ammonium citrate solution add 30 ml. of 30-volume hydrogen peroxide (stabilised with sulphuric acid).

Procedure

Transfer 120 ml. of aqueous iodine/potassium-iodide to a 300-ml. "carbon dioxide" flask fitted with a mechanical stirrer and nitrogen tubes. Immerse the flask in cold running water and stir for 30 mins. with nitrogen passing through the solution. At the end of this period, rapidly introduce 5 g. of sample in the form of drillings. Continue to pass nitrogen and stir for 3 hr., keeping the flask immersed in running water throughout. Filter the solution through a Whatman No. 42 filter paper (4.25-cm.) contained in a small Büchner funnel, applying gentle suction, and wash free from iodine with 5 per cent. potassium iodide solution and cold water. Transfer the paper and precipitate back to the original flask, add 120 ml. of sodium carbonate-citrate solution, place the flask in a water-bath at 80 deg. C. and stir for 30 mins. Filter the solution as before and wash well with hot 2 per cent. sodium citrate and hot water. Place the paper and precipitate in the original flask, add 200 ml. of peroxide-citrate solution and again stir for 2 hr. at 80 deg. C. Filter on a Büchner funnel as previously, washing with hot 2 per cent. ammonium citrate and water. Next stir the residue as before with 200 ml. of ammonium citrate solution for 2 hr. Filter, wash with hot dilute ammonium citrate solution and water and again stir with citrate reagent for 30 mins. Filter the solution and observe whether or not the filtrate is free from yellow coloration. If this be the case, wash with hot 2 per cent. ammonium citrate and hot water, and finally stir the residue with 120 ml. of carbonate-citrate solution for 30 mins. Filter, wash as before, and transfer the pad and precipitate to a 150-ml. beaker. If the filtrate be yellow in colour, the residue should be stirred in it for a further 30 mins. (making one hour in all). Repeat the filtration and washing and treat for a further 30 mins. with citrate reagent; again filter, and examine the filtrate. This series of operations should be repeated until the final filtrate is free from yellow coloration. The residue is finally treated with carbonate-citrate solution as previously described.*

To the residue in the beaker, add 10 ml. of concentrated sulphuric acid and 10 ml. of concentrated nitric acid and heat gently until sulphuric trioxide fumes are evolved. Allow to cool and add 2 or 3 ml. of fuming nitric acid from a spotting bottle and again evaporate to fumes. Repeat these additions of fuming nitric acid until all graphite and other carbonaceous matter have been removed. Cool, dilute to 50 ml., boil, and filter off silica on a Whatman No. 42 filter paper; wash the precipitate with hot 5 per cent. sulphuric acid and cold water. Ignite the silica, etc., in a platinum crucible and treat it with a few drops of 20 per cent. sulphuric acid; heat to expel excess sulphuric acid and ignite to constant weight. This procedure ensures that any elements forming stable sulphates are weighed in this form after ignition. Remove silica by volatilisation with hydrofluoric acid in the presence of sulphuric acid in the usual manner.

Fuse any residue remaining after the removal of silica with 0.5 g. of potassium bisulphate and extract the melt in the main solution.

The remainder of the analysis may be outlined briefly as follows:—

(1) Iron, titanium, vanadium and zirconium (if present) are precipitated with cupferron. The residue is ignited, fused with bisulphate and the constituents determined colorimetrically.

(2) The excess cupferron in the filtrate from the above separation is destroyed with sulphuric and nitric acids and the resulting solution used for the determination of manganese, aluminium and phosphorus. Manganese is determined by the periodate, aluminium by the aurintricarboxylate, and phosphorus by the ammonium-molybdate/stannous-chloride method.

Notes on the Revised Aqueous Iodine Method

(*a*) Throughout the development of the above procedure, a careful check was kept on the impurities introduced from chemicals and glassware. Recent determinations of blank values have shown that, although further treatments have been incorporated, no appreciable increase has taken place. The average total blank, including ash from filter papers, is as follows:—

SiO_2.	Fe_2O_3.	Al_2O_3.	MnO.
Per cent.	Per cent.	Per cent.	Per cent.
0.00040	0.00018	0.00008	Nil

(*b*) All analytical determinations, with the exception of that of silica, are now made colorimetrically, a Lovibond tintometer being used for colour measurement.

(*c*) Attempts were made to apply colorimetric methods to the determination of silica. Two methods were examined, viz., one based upon the yellow silico-molybdate colour, and the other on the blue colour obtained by reducing the latter compound. Neither procedure was found to be sufficiently sensitive for the accurate determination of the small amounts of silica present in non-metallic residues.

Development of the Revised Procedure

The original modified aqueous iodine procedure yielded results for total oxygen which were, generally speaking, in good agreement with those obtained by the vacuum fusion method on the same materials. There were, however, as indicated at the time, problems which called for further investigation. Some preliminary work on the behaviour of manganous oxide was also reported previously, and it was stated that reliable results for this oxide could be obtained by the procedure if the washing of the residue with ammonium citrate solution were omitted, since this latter reagent appeared to dissolve manganous oxide. Subsequent work showed this statement to be erroneous, since, whilst synthetically prepared manganous oxide is but slightly soluble in aqueous iodine/potassium-iodide, it is readily dissolved by this solution in the presence of iron.

The Behaviour of Manganous Oxide.—A recent study of the variations in hydrogen-ion concentration during the decomposition of iron by aqueous iodine/potassium-iodide revealed the fact that on adding the iron to the iodine solution, which has an initial *p*H value of 6.1, the temperature rises very rapidly, in spite of water-cooling, and the *p*H value falls equally rapidly to about 1.0; the actual fall varies slightly with the particular type of iron concerned. Thus, the acidity of the solution approaches that of N/10 acid about 15 min. after adding the iron sample. These experiments have provided an

[1] Eighth Report on the Heterogeneity of Steel Ingots, pp. 121–138, Iron and Steel Institute, 1939, Special Report No. 25.

**Note.*—For all the pig-iron samples so far examined, a period of 2hr. with ammonium citrate, after the peroxide-citrate treatment, has proved sufficient to yield a colourless filtrate on further testing.

explanation for the apparent differences in the behaviour of synthetic manganous oxide to which reference has already been made.[1] It has been stated by Klinger and Koch[2] that manganous oxide is soluble in solutions having a *p*H value below 5.0, so that it is to be expected that it will readily dissolve in the aqueous iodine solution if iron is present. This was confirmed by experiments using synthetically prepared manganous oxide. It was also shown that the oxide is completely soluble in hot ammonium citrate solution. Attempts to bring about the decomposition of the iron in iodine solutions of controlled *p*H value (5.0 to 6.0) have so far failed owing to hydrolysis of the iron; if citrates or tartrates be added to avoid the latter, manganous oxide is dissolved. The conclusion has therefore been reached that the aqueous iodine method does not yield results for manganous oxide, existing as such, but from a consideration of the chemical properties of manganese silicate, the author is of the opinion that, if it exists combined with silica in this form, it remains in the final non-metallic residue. Thus, the small amounts of manganese oxide found in pig-iron residues appear to have existed originally as silicate.

The study of variations in *p*H values and in temperature suggests that the decomposition of the iron by the iodine solution is complete in a comparatively short time (15 to 20 mins.) and that the additional time required to obtain a residue suitable for further treatment is occupied by the conversion of iron phosphide to phosphate.

The Behaviour of Manganese Sulphide.—Experiments carried out with synthetically prepared samples of manganese sulphide, along similar lines to those used in examining the behaviour of manganese oxide, showed that the sulphide is not completely decomposed by aqueous iodine in the presence of iron; approximately 90 per cent. passes into solution. It is, however, completely soluble in hot ammonium citrate solution, so that it is concluded that manganese sulphide causes no interference in the modified process.

It appears probable, in the light of this recent work, that the manganese obtained in the residues referred to above when omitting the citrate treatment was due, not to oxide, but to small amounts of undecomposed sulphide.

The Behaviour of Iron Carbide.—A few years ago, Bihet and Willems[3] extracted iron carbide from a sample of Swedish white iron and examined its solubility in a variety of solvents; they reported that the carbide is most soluble in cuprous ammonium chloride, less soluble in alcoholic iodine, and least soluble in aqueous iodine solutions.

More recently, Bramley, Maddocks and Tateson[4] suggested that the iron carbide present in steel specimens containing more than 0.6 per cent. of carbon causes serious interference when the alcoholic iodine method is employed to separate the non-metallic residue from such materials.

It appeared probable, therefore, that the aqueous iodine method would be subject to such interference from iron carbide, especially in view of the work of Bihet and Willems. The preliminary work on samples of grey iron gave no indication that such interference was occurring, but the problem was investigated by an examination of synthetically prepared white irons having a combined carbon content of 3.2 per cent. and a silicon content of 2 per cent. Silicon was added in order to reduce the amount of ferrous oxide in the material.

When this material was examined by the standard procedure, it was found that the initial residues contained unusually large amounts of iron and, moreover, consistent results could not be obtained. After the application of the ammonium citrate treatment, however, the amounts of iron found were consistent and of a much lower order than previously. It was therefore concluded that iron carbide causes no interference in the modified aqueous iodine process.

From the results obtained on these synthetic white irons it would appear that iron carbide is only partially decomposed during the initial attack with aqueous iodine, but that the small amount remaining is completely removed by treatment with hot ammonium citrate solution.

The Behaviour of Iron Oxide.—The general results obtained by the original procedure suggested that, in spite of the acidity of the final iodine solution, oxides other than that of manganese and silicates are unattacked. This is to be expected from the known chemical properties of such oxides as those of silicon and aluminium, although the behaviour of iron oxide is less certain.

In the original work the procedure developed was applied to a very limited number of irons, and when in subsequent tests this range was greatly extended it was found that, in certain cases, abnormally high figures were recorded for iron oxide; in these cases it was observed that a second treatment with ammonium citrate yielded a filtrate which was still yellow in colour. It was subsequently found that if citrate treatments were applied until a colourless filtrate was obtained, consistent figures for iron oxide, of a much lower order than previously, were obtained. This modification was therefore incorporated in the new standard procedure. The application of this latter method to a series of over forty irons has given evidence that ferrous oxide is not appreciably attacked during the decomposition of the material by aqueous iodine/potassium-iodide. The total oxygen results calculated from the aqueous iodine figures are in good agreement with those obtained directly by other methods, particularly the modified aluminium reduction procedure, to which reference is made later.

The Determination of Silica.—The application of the original procedure to a wider variety of materials revealed the fact that in certain cases the recommended treatment with sodium carbonate-citrate solution failed to remove the whole of the silicic acid present. Evidence of this was provided by the fact that the oxygen equivalent of the recorded silica percentage was in excess of the *total* oxygen given by the modified aluminium reduction process. It was found necessary to repeat the carbonate-citrate treatment after the application of the other treatments. When this was done no further trouble was experienced, and this procedure was also adopted as standard. It was also found that the results for silica were improved by substituting wet oxidation for ignition as a means for removing carbon, etc.

The Behaviour of Titanium.—From the commencement of the work on the aqueous iodine method it was observed that the whole of the titanium present in the iron remains in the final non-metallic residue.

Recent results have indicated that the amounts of oxide inclusions in pig-iron are of a much lower order than was at first assumed. Further, none of the treatments so far devised had had the slightest effect upon the titanium content of residues, and analysis was therefore being carried out in the presence of comparatively large amounts of this element. It occurred to the author that this titanium might be removed from unignited residues by treatment with hydrogen peroxide.

Preliminary tests showed that titanium carbide was soluble in ammonium citrate solutions containing hydrogen peroxide, but experiments with neutralised hydrogen peroxide alone failed owing to hydrolysis of the titanium.

Accordingly hydrogen peroxide was added to the ammonium citrate solution used for treatments, and it was found that in most cases this removed the whole of the titanium from the residue without appreciable influence on the oxides present. In a few cases, viz., those of irons containing 0.3 per cent. or more of titanium, a trace (0.01 per cent.) remained in the final residue, but was insufficient to complicate the analysis. Further, this application of peroxide-citrate solution instead of citrate alone halved the time required for the decomposition of iron carbide. This change was therefore made in the standard procedure.

The Behaviour of Phosphorus.—In the original work it was shown that, whilst iron phosphide is relatively insoluble in ammonium citrate solution, iron phosphate is soluble under the conditions laid down in the standard procedure. It was also observed that in spite of this solubility of the phosphate in the reagent, it was impossible to remove every trace of phosphorus from the residues, even by very prolonged treatment with hot citrate solution; the amount remaining was equivalent to about 0.01 per cent. of P_2O_5.

In the more recent work it was found that when treatments were carried out with citrate solutions containing hydrogen peroxide, not only was titanium removed from the residue but the small traces of phosphorus hitherto found also disappeared. In every case where the titanium content of the residue was nil, phosphorus could not be detected by the sensitive colorimetric method employed.

It would therefore appear that this final trace of phosphorus is in some way connected with titanium, and is not combined with calcium and magnesium as was originally suggested. In this connection it is noteworthy that the results of all tests so far made for calcium and magnesium have been negative in character in spite of improved analytical technique.

Conclusions

From the work carried out since the publication of the original aqueous iodine method the following conclusions may be drawn:—

(1) The solution of manganese oxide, as such, during the decomposition of samples by aqueous iodine/potassium-iodide cannot be prevented, and hence results for this oxide cannot be obtained at present.

(2) Iron carbide, iron phosphide, manganese sulphide and titanium carbide cause no interference in the new procedure.

(3) The modifications introduced surmount the difficulties which had arisen during the more general application of the method originally suggested.

(4) The present procedure has been successfully applied to a series of forty-five types of pig-iron without further complications: it is therefore believed that the process may be employed for the determination of oxide inclusions in all types of pig-iron, excluding alloy irons, and that results for SiO_2, FeO, MnO (existing as manganese silicate) and Al_2O_3 are reliable.

(To be continued.)

[1] Eighth Report on the Heterogeneity of Steel Ingots, pp. 121–138, Iron and Steel Institute, 1939, Special Report No. 25.
[2] Klinger and Koch, Technische Mitteilungen Krupp, Forschungsberichte, 1938, No. 3, May, pp. 49–65.
[3] Bihet and Willems, Archiv für das Eisenhüttenwesen, 1937, vol. 11, Sept., pp. 125–130.
[4] Bramley, Maddocks and Tateson, Eighth Report on the Heterogeneity of Steel Ingots, pp. 11–25, Iron and Steel Institute, 1939, Special Report No. 25.

Testing of Stainless Steel

H. W. Russell, H. Pray and Paul D. Miller, of the Battelle Memorial Institute of Columbus, Ohio, have described the development of a small electrolytic cell for attachment to a fabricated article of stainless steel to determine in 3 min. whether or not it will resist corrosion. The electrolytic cell solution acts on the surface, and by the appearance of the spot acted on, it is possible to determine whether or not the particular part is subject to corrosion. The test is non-destructive and can be applied to a completed structure.

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Institute of British Foundrymen

LANCASHIRE BRANCH

The annual general meeting of the Lancashire Branch of the Institute of British Foundrymen was held at the Engineers' Club, Manchester, on April 5, Mr. W. Holland, Branch-President, in the chair.

Loss by Death

The PRESIDENT announced with regret the loss by death of a very old and respected Past-President of the Lancashire Branch, Mr. Sidney G. Smith, owing to enemy action. Mr. Smith was an honorary life member of the Institute, and wrote several articles on foundry practice, besides lecturing extensively. The members rose in silent appreciation of the memory of the deceased member.

Minutes

The minutes of the previous annual meeting of the Branch, held at the Engineers' Club on April 1, 1940, were read by the secretary.

Upon the motion of Mr. E. J. L. Howard (Manchester), seconded by Mr. A. Sutcliffe (Bolton), the same were unanimously approved and adopted, as a correct record.

Financial Statement

MR. W. N. COOK (Stockport) announced that the affairs of the Branch had been administered in an extremely economical way, and moved the adoption of the financial report of the Branch.

The motion was seconded by Mr. A. Jackson (Accrington) and carried unanimously.

Auditors' Report

MR. A. HOPWOOD (Liverpool) and MR. R. R. HARGREAVES (Manchester) reported that the books and the accounts of the Branch had been properly kept, and certified that the balance sheet was a true and correct statement of the Branch finance.

Hon. Secretary's Annual Report

MR. A. BOYES, hon. secretary of the Branch, then presented his annual report as follows:—

The period covered by this report, while being one of anxiety and, in a few cases, of distress is nevertheless, as far as the Lancashire Branch is concerned, a successful one, during which Branch meetings have been maintained at a high level. The January meeting had most unfortunately to be cancelled, but all other meetings have been held; and the number of attendances recorded at each meeting have been well up to the average for past years.

The statement of accounts shows a slight increase in expenditure over the past year of about £2, but a decrease of over £20 against the last few years. This has only been accomplished by the most rigid economy, for it must be borne in mind that postage has now practically doubled itself, and the cost of stationery has considerably increased. It is gratifying to be able to record that subscriptions received during the year showed a marked increase over the previous year, thereby contributing towards the large balance in hand on December 31.

Since the last report 26 new members have been added to the Branch, but against this there have been a number of resignations. The membership of the Branch at present stands at 387. The Branch has suffered particularly heavy losses through deaths. Amongst these, Mr. R. A. Miles was perhaps the best known, and his active and cheerful personality will be sorely missed.

Mr. A. Hopwood has been honoured with the Diploma of the Institute, and Mr. A. Sutcliffe by the Branch with the "R. A. Jones" Medal of Merit.

The Burnley Section have had another successful year, although they found it necessary to cancel their December meeting. Their financial position is quite sound.

So far as the social activities of the Branch are concerned, it has been found necessary to cancel all social functions, and, of course, works visits are out of the question at such a time as the present.

In concluding his report, the secretary wished to offer his sincere thanks to the President, Mr Holland, and members of the Branch Council and also the staff at the General Office for the support and assistance so readily accorded at all times.

MR. A. PHILLIPS (Manchester), in moving that the hon. secretary's report be approved and accepted, congratulated Mr. Boyes upon having carried on the secretarial work of the Lancashire Branch so successfully during a particularly trying time. While regretting that they had lost the services of the previous secretary, Mr. J. E. Cooks, he thought they were extremely fortunate in being blessed by so good a successor, who was able to carry on the Branch business in full accordance with the best traditions of the past.

MR. E. LONGDEN (Manchester), in seconding the adoption of the report, said that anything further than what had been stated by the mover would be superfluous. He would merely echo Mr. Phillips' remarks, and had great pleasure in seconding the motion.

Appointment of Scrutineers of Ballot Papers

Mr. Harold Haynes, Mr. Pell, Mr. Alec Jackson, and Mr. Brown were appointed scrutineers of the ballot papers to be issued in connection with the election of the Branch officers.

The Retiring President and Officers

Upon the motion of Mr. A. Phillips, which was duly seconded, a hearty vote of thanks was accorded to the retiring President and other officers for their services to the Branch during the past year.

Election of Officers

During the course of the discussion it was resolved that Mr. W. Holland be re-elected as President of the Branch for a further term of office, and that Mr. E. J. L. Howard be senior vice-president. Mr. A. Hopwood was elected junior vice-president.

The following were appointed as members of the Branch Council for a period of three years: Mr. R. R. Hargreaves, Mr. W. Brown and Mr. S. Brooks.

Mr. A. Phillips, Mr. J. Jackson, Mr. A. L. Key and Mr. Norman Cook were elected as Branch representatives on the General Council.

Mr. A. Phillips and Mr. J. Jackson were re-elected representatives of the Branch on the Technical Committee of the Institute.

Mr. A. Boyes was re-appointed hon. secretary and treasurer, and Mr. F. A. Harper was re-appointed assistant secretary.

The hon. auditors appointed were: Mr. A. Hopwood (Liverpool) and Mr. R. R. Hargreaves (Manchester).

Presentation to Mr. A. Sutcliffe

The Branch then paid an especial honour to Mr. A. Sutcliffe. The "R. A. Jones" Gold Medal was presented to him as a token of the value the Council and the members of the Branch attached to Mr. Sutcliffe's contributions to the discussions following upon the reading of the various Papers which had been presented for consideration during the 1940-41 session.

For the past 26 years Mr. Sutcliffe has been associated as foundry foreman with Messrs. Jackson Bros., Limited, Wharf Foundry, Bolton.

The Branch-President, MR. W. HOLLAND, in making the presentation, said that Mr. Sutcliffe had not merely earned his title to the medal but had also kept the Branch alive and vigorous by his criticisms and by stimulating the criticisms of others. His good work in this respect had been noticeable not only during the past session, but also for many sessions previously. It was with very great pleasure that he presented the "R. A. Jones" Medal, suitably inscribed, to Mr. Sutcliffe, and he hoped that that gentleman would live long to treasure it.

MR. SUTCLIFFE, in returning thanks for the presentation, confessed to experiencing a great feeling of pleasure at having won the medal. His thanks were due also to its donor, Mr. R. A. Jones, who unfortunately could not be present upon that occasion. Mr. Jones had now left the foundry world, and had taken up another phase of business life, so he would take the opportunity to wish him success in his new calling.

Mr. Sutcliffe, continuing, said that some people might state he possessed the "gift of the gab," but even if that were true no one ever yet heard him make a statement the accuracy of which he was not prepared to substantiate at any time. Moreover, he was quite ready to pick up his tools and demonstrate in a practical manner any of the propositions he had advanced during the course of the discussions, if anyone requested him to do so.

Presentation to Mr. A. Hopwood

The Diploma of the Institute was awarded to Mr. A. Hopwood for his Paper entitled "Phosphor Bronze Castings of Heavy Sections," as presented before the London Branch, and which was published in THE FOUNDRY TRADE JOURNAL on October 26, 1939.

The presentation to Mr. J. E. Cooke, in recognition of his past services to the Lancashire Branch, was by proxy, as that gentleman was unable to be present at the meeting.

The meeting concluded with a general discussion upon "Foundry Problems," which was opened by Mr. A. Sutcliffe (Bolton).

U.S. Aluminium Industry

Primary aluminium production in the United States in 1940 exceeded the 1939 peak by 26 per cent., and consumption rose 35 per cent. above that in 1939, according to the U.S. Bureau of Mines. A total of 206,280 net tons of new aluminium was produced in 1940, contrasted with 163,545 tons in 1939. The apparent consumption of primary aluminium in 1940 totalled 227,017 tons, compared with 167,669 tons in 1939. At the end of 1940 aluminium was being produced at a rate exceeding 250,000 tons annually. In order to meet the requirements of the national defence programme, aluminium production will be further increased in 1941 and 1942 at the five reduction plants of the Aluminium Company of America and at a new plant of the Reynolds Metals Company in Alabama. Output is expected to reach an annual rate exceeding 345,000 tons by July, 1941, and 422,500 tons by July, 1942.

According to official trade returns, imports of aluminium ingot, alloy, scrap, plates, etc., into the United States increased from 14,336 tons in 1939 to 18,089 tons in 1940, a 26 per cent. advance in quantity. Exports of domestic crude and semi-crude aluminium in 1940 were exceeded only by the record shipments in 1939, and totalled 27,841 tons, compared with 37,084 tons in 1939, a decrease of 25 per cent. Imports were chiefly from Canada (15,249 tons) and France (2,506 tons), and exports were chiefly to the United Kingdom (10,945 tons).

Plant for the Melting of Aluminium and its Alloys*

In order that consistent and successful results may be obtained in the routine melting of aluminium alloys, it is essential, first, that furnaces employed for these purposes be so designed, constructed, controlled and used that the metal, both in the molten and solid states, is given no opportunity to react in any way disadvantageously either physically or chemically.

Such conditions apply, in general, to all furnaces for the melting of any metals. Aluminium alloys, however, in spite of their relatively low melting points, entail special considerations. These are dictated by the chemical reactivity of the molten metal.

Again, as for other metals and alloys, the heating medium used may be a solid fuel (usually coke), oil, gas (mainly coal gas), or electricity. For melting purposes, examples may be cited of the use of all four systems.

Conditions Governing Choice of Heating Medium for Melting

The partiality shown for any given heating medium will be governed by both technical and economic considerations. Because of the close temperature control required when melting aluminium-base alloys, there is, naturally, a bias towards those fuels which simplify this particular problem; electricity, gas and oil are, in this respect, manifestly superior to solid fuels; for very large continuous outputs of molten metal, instances may be quoted of the successful use of the last-named medium.

The necessity for preventing contamination of a light-alloy melt from products of combustion is well known. Thus, the absence of such sources of contamination operates in favour of electric melting. On the other hand, correct furnace design and careful supervision of the fusion process tend largely to offset any possible disadvantages which might be attributed to liquid or gaseous media. Attempts, therefore, to assess the relative merits of any firing system solely on chemical or physical grounds, are apt to lead to false conclusions, as a survey of accepted practices in various countries will readily show.

Providing that all requisite technical conditions may satisfactorily be fulfilled, namely, rapid heating, ease of temperature control, and full protection of the molten charge against the possibility of gas absorption from combustion products, economic factors tend largely to determine the medium finally selected. In those situations where electric power is cheap, wide use will probably be made of this source of heat. Where gas fuel of standardised thermal and chemical qualities is readily available, such a medium has obviously everything to recommend it, whilst the cheapness of fuel oil, its ready availability and the ease with which it may be stored, may, in other environments, dictate that this be the most suitable fuel.

It cannot be too strongly emphasised that, in choosing a heating system for general industrial use, selection based solely on a thermal balance sheet is of little value. Of the utmost importance, however, is the fact that a medium having been selected with due regard to technical and (local) economic requirements, then that medium, for its most satisfactory and efficient use, demands, first, correct furnace design and construction for the work in hand, and, secondly, correct furnace operation.

Types of Melting Furnace

Melting furnaces for aluminium and its alloys range in size from those with an aluminium capacity of 50 lbs. or even less, up to plant capable of melting 20 tons or more. For charges up to ½ ton, crucible furnaces are most conveniently used, whilst for those above 2,000 lbs. reverberatory furnaces are more satisfactory. Under each of these two headings are comprised various modifications of the main design, the precise type selected depending upon whether continuous or batch operation is desired and upon the use to which the metal is to be put.

Influence of Heating Medium on Design of Melting Furnace

For each type of heating medium, it is necessary so to design and arrange the structural details of the furnace that no operating difficulties arise either in connection with the molten charge or with the heating mechanism. Thus, the oil- or gas-fired reverberatory furnace, in which the products of combustion contain hydrogen or water vapour capable of yielding hydrogen in contact with the molten metal, should, as a rule, be so designed that the combustion space is screened from the melt. The resistance-type electric furnace of fundamentally similar design must be so constructed that the heating elements are protected from splashes of molten metal, otherwise they may be rapidly destroyed.

Coke-fired crucible furnaces are frequently of the lift-out or pit type, and are mainly of small size (50- to 100-lb. aluminium capacity). Structural difficulties tending to hinder the development of successful coke-fired tilting furnaces (which are usually required when handling large amounts of metal unless it be intended for the charge to be ladled out) have been overcome in some successful modern designs, and capacities up to 220 lbs. are available.

Portable melting furnaces are usually of the coke-, gas- or electrically-heated types; the two first-mentioned media are most commonly employed. Such furnaces are, as a rule, of small size, say 50- to 100-lb. aluminium capacity, and are designed principally for small jobbing foundries. This type is usually provided with forced draft, whilst larger fixed forms may be of the forced or natural draft variety.

Structural Materials for Melting Furnaces

Because of the low temperature at which aluminium alloys melt, difficulties encountered in the selection of refractories for metals of high melting point do not, in general, arise in light-alloy practice. Spalling and erosion phenomena will be met only in the combustion chambers of gas- or oil-fired furnaces, or at the exterior of crucibles used in such plant, and even then, only when shortcomings in design allow of different high-temperature flame impingement. The elimination of this fault is catered for by a number of very effective designs, which, whilst preventing the occurrence of local overheating, ensure nevertheless the most rapid and uniform transference of heat to the charge, whether by reverberation or indirectly via the walls of a crucible.

Although the temperature of the metal in contact with the crucible or furnace hearth will not exceed about 800 deg. C., due account must be taken of the possibility of its reacting with the material or materials, of which these are composed. Aluminium and aluminium-base alloys are, in the molten state, powerful reducing agents, and, in the presence of silica and iron oxide, may, under certain conditions, tend to abstract oxygen from these compounds, this process resulting in the charge becoming unduly enriched in silicon and iron, besides becoming contaminated with aluminium oxide (frequently in the crystalline form) simultaneously produced.

Non-Metallic Refractories

For hearth-type furnaces, sillimanite or high-grade fire-clay are, both technically and economically, satisfactory refractories for use in those parts subjected to the action of the molten metal. For crucibles, kaolin-graphite or plumbago, silicon-carbide, or close-grained (well annealed) grey iron are satisfactory.

Graphite mixtures and silicon-carbide are good conductors of heat and are not attacked by the melt; the former, if used in an electrically-heated furnace must, as a rule, be glazed on the exterior, as otherwise it tends to lose graphite by oxidation and may become dangerously weak. This is so because the electric furnace does not give rise to the reducing atmosphere encountered with other heating systems. Silicon-carbide crucibles are expensive, but give a very long service life; they are, however, far less commonly used than graphite crucibles, the service life of which is also long.

Cast-Iron Pots

Because of its higher mechanical strength, the cast-iron pot is much favoured for all types of crucible-furnace for aluminium melting. It is important to note that the pressed-steel pot commonly used for magnesium-base alloy melting cannot safely be used for aluminium, which exerts a powerful solvent effect upon iron in this form. Some solvent action will occur with the cast iron, unless the inner surface of the pot be treated with a protective wash (a 50 per cent. kaolin suspension in water, containing about 5 per cent. of water glass as a binder, is widely used), which must be applied regularly to the cleaned surface daily.

Even with this precaution, however, it is difficult entirely to inhibit some dissolution of the iron which, in the case of high-strength or corrosion-resistant alloys, may result in a reduction in mechanical strength and in their resistance to chemical attack; for such alloys, therefore, graphite pots are recommended.

Structural Materials Other than Refractories

The remaining materials used in the construction of furnaces, other than in special oil burners or gas nozzles, will be cast iron for frames, mild-steel sheet (welded or riveted) for external plating or casing, less-refractory ceramic masses for backing the refractories proper of the hearth or combustion spaces, and insulating refractories, such as diatomite to increase thermal efficiency by decreasing heat-loss by radiation or transference to the outer casing of the furnace. The induction furnace requires special consideration with regard to the refractories employed in its construction; these will be considered when this furnace is dealt with.

General Details of Melting Furnace Operation

Irrespective of furnace design, and of the alloy or alloys being melted, certain conditions must be satisfied if a faultless melt is to be obtained. The first concerns the avoidance of gas contamination of the charge. In the case of town's-gas fired furnaces, the gas used may be assumed to be standardised with respect to both thermal and chemical characteristics. Provided that furnace design be correct, that combustion conditions are accurately adjusted, and that crucibles, if used, be in good condition, and are of such a size as to fit accurately into the furnace and provide a seal against the escape of burnt gases in the neighbourhood of the molten-metal surface, no difficulties are to be anticipated if the whole furnace structure, including crucible and lining, has been thoroughly dried out before production melting has started, by running without a charge or with light pilot charges; this operation may, according to circumstances, take from a few hours to one or more days.

* Data issued by Aluminium Union Limited in their house organ "Aluminium Technique."

This "curing" procedure is of the utmost importance and, coupled with some system of accurate temperature control, must be followed for every type and size of melting furnace, whatever fuel or heating system be used. In the case of cast-iron pots, upon which moisture may condense if they are allowed to cool, care should be taken to dry off before inserting a fresh charge.

Oil-fuel furnaces require careful regulation of the oil/air ratio to ensure perfect combustion, whilst the coke used for coke-fired plant should be stored in perfectly dry bunkers in order to avoid the production of steam in the combustion chamber whence it may penetrate to the charge, and, decomposing in contact with the molten metal, contaminate this last with hydrogen and aluminium oxide.

Thermal Control

Temperature measurement of the melt in crucible furnaces is best carried out with thermocouples of the immersion type, the hot junction being unsheathed in order to avoid time-lag in recording and thus to eliminate the danger of even momentary overheating. Pyrometers used in conjunction with automatic-temperature-control equipment and fixed pyrometers in large hearth furnaces must be of the sheathed type, but the sheath should not be unduly thick, otherwise recording will be slowed down.

There is little need to emphasise the need for the charge, whether of virgin ingot or of scrap, to be clean, dry, free of grease (cutting compounds, for instance) and uncontaminated with carbonaceous or other reactive dusts. Foreign substances of these types invariably result in the production of gassy melts.

Particularly when running down small scrap, or scrap purchased from outside sources (as distinct from work's scrap run down *in situ*), various fluxes, of which a number of proprietary brands are obtainable, are frequently used. Their purpose is to remove entrapped oxides, clean up the melt and sometimes to remove unwanted constituents, such as magnesium from the bath. These substances should be used according to instructions; wrongly employed, they entail needless expense and may tend to reduce the life of the hearth or the crucible. When melting down, and when pouring, no needless stirring should be imparted to the metal as gas entrapment may be caused. When alloys are being made, however, care should be taken to see that the melt is rendered homogeneous by careful mixing.

Reverberatory or Hearth-Type Melting Furnaces

Reverberatory furnaces may be designed for continuous or batch operation, these two principal types being characterised by certain structural differences. The former type, in so far as it presupposes the constant maintenance of a bath of molten metal, is usually provided with a forehearth upon which new metal for the charge is laid in order to preheat it, and thus prevent chilling of the melt into which it is ultimately pushed or run.

The intermittent type has no forehearth, the bath being loaded, after pre-warming, with the necessary ingot and/or scrap, which is then run down, and, after attaining the correct temperature, tapped off, ladled out, or run off by tilting the furnace.

Plant of this type may be of the fixed, tilting, rocking or rotary types, the last two being especially valued in some quarters for scrap melting, or for alloy manufacture, as they ensure adequate homogenisation of the charge. The tilting type is favoured for batch operation as complete emptying of the bath is facilitated. The fixed type can be adopted for ladling or for discharge by means of a tap-hole of the conventional sort.

It will have been observed that special uses have been indicated for certain designs. In common with other plant, the tendency has been for design gradually to evolve around certain particular requirements, and the precise type of melting equipment selected will depend, not only upon actual or projected outputs, but also upon the nature of the product manufactured, whether ingots or castings. The size and output of the latter will also be determining factors. No hard-and-fast rules can be laid down, and predeliction for one or another type varies somewhat in different countries.

Reference has already been made to outstanding differences in the design of hearth furnaces for electric heating, gas or oil firing and coke firing. Mention must be made of hearth furnaces in which heating is by means of gas-fired radiant tubes located on the hearth itself, and, in operation, actually immersed in the melt. The success of this system for aluminium depends upon the development of a tube material sufficiently resistant to the prolonged action of the molten metal; difficulties in this connection do not occur with most metals of low melting point, where interaction, if it occurs, is soon inhibited by a layer of intermetallic compound which diffuses inwards very slowly.

The gas-fired radiant tube-heated furnace, and the resistor-type electric melting furnace would appear automatically to solve the problem of gas contamination of the melt. From a thermal standpoint the former should be notably efficient, as heating takes place both by radiation and convection, there being no poor-conducting layer, or protective screen, between the metal surface and the source of heat.

The highly efficient arc-furnace, widely employed for the melting of metals and alloys with high fusion temperatures, cannot be satisfactorily employed for the light alloys owing to technical difficulties associated with the economical distribution of the intense heat generated by the arc and radiated by the furnace arch.

Crucible Melting Furnaces

Crucible furnaces may be of the gas, oil, coke, or electrically heated types, and may be of fixed (lift or bale out) or tilting design. Included in this group are the maintaining furnaces, employed, in conjunction with larger melting furnaces proper (of either the hearth or crucible type), for holding smaller quantities of metal at a given temperature; they are technically convenient, metal being run into them from the large unit, and then ladled out as required for gravity or pressure die-casting purposes. Crucible furnaces and maintaining furnaces are made in capacities up to 1,000 lbs.

In the case of the coke, gas, and oil-fired types, one feature of design needs special mention. The crucible should be so mounted within the combustion zone that no escape of burnt gases can occur around the edges of the pot, thus permitting them to come into contact with the melt. Considerations with respect to crucible life dictate that combustion-chamber and burner design of gas and oil furnaces be such as to guard against direct flame impingement, whilst uniform temperature distribution in the melt is promoted by the same measures and by correct design and location of flues.

Electrically-heated pot furnaces may be of the resistor or low-frequency induction type. The former is very simple in construction, consisting in its modern form of a cylindrically wound nickel-chrome heating element (this material giving long life and perfect satisfaction, as the temperatures employed for aluminium melting do not exceed 700 to 800 deg. C.) mounted in a suitable refractory and heat-insulating casing, the crucible being located centrally within it. The only special feature of the design of such furnaces is the provision of a run-out in the casing; this is to guard against the destruction of the resistor, should by any chance the crucible break and the contents run out into the furnace body.

The low frequency induction melting furnace has been in use for some years for the melting of brasses and bronzes. Recently it has become increasingly popular for aluminium melting by reason of the absence of any possibility of contamination of the melt by gases. In principle, it consists of a transformer, the primary winding of which is designed to carry a moderately heavy current at main's frequency and voltage. The melting space corresponding to the crucible, is of special form, being so shaped as to give an annular cavity at its base, this cavity being centred around a low-hysteresis laminated magnetic core. The "ring," when full of molten metal, constitutes the secondary winding of the transformer.

Ring and melting space proper are formed by ramming refractory sand with a boric-acid bond around a pattern located in the furnace casing. Before the furnace can operate, the "ring" must be filled with molten metal, the purpose of which is to carry the secondary current, the heat generated by which being then transmitted to the solid charge in the "crucible." When pouring, a residue of molten metal must always be left in the ring. Furnaces of this type, which are always of tilting design, give rapid melting and are especially suitable for handling high-strength alloys, for, not only is the heating effect very uniform, but the rotary motion imparted to the charge promotes maximum homogeneity. After some time, the "ring" tends to become choked with oxide, which is removed by entirely emptying the furnace and drawing a hooked chain through the annulus.

Low-frequency induction furnaces are highly efficient, as not only is the energy input converted into heat within the charge but, in addition, maximum thermal insulation may be provided by reason of the simplicity of the design; the refractory lining actually forms part of the heat-insulating system. Incidentally, the swirling of the charge under the influence of the current tends to scour the refractory walls of the melting space and "ring"; hence great care must be taken to ensure adequate ramming to give a wear-resistant "smooth" surface.

Commercially Produced Lithium

H. OSBORG, writing in a recent issue of "Metal Progress," states that metallic lithium has acquired commercial importance, and that lithium metal and alloys containing 30 per cent. of lithium and more, have been produced on a commercial scale. In order to obtain a proper conception of the still young industry, one must consider the low specific gravity of lithium (only one-half that of water). Also, lithium is added in amounts of but 0.005 to 0.025 per cent. to treat molten metals and alloys. Taking 0.015 per cent. as an average, 0.3 lb. of lithium suffices for one ton of metal. In other words, each 1,000 lbs. of lithium corresponds to more than 6,500,000 lbs. of treated metals, like copper or copper alloys, produced and marketed.

Wooden Water Mains of Old London

In the reign of James I, Hugh Myddelton conceived the idea of bringing water by means of a canal from springs near Ware, in Hertfordshire, to London. When the water was brought to the river-head, in Clerkenwell, it was decided to convey the water under the streets by means of hollowed tree trunks. Two quaint specimens of this experiment have recently been unearthed by Gray's Inn Road, near King's Cross. The trunks are about 12 ft. long, having an average of 15 in. dia. and a bore of about 7 in. Mid-way between the outer edge of the trunk and the outer edge of the boring is a circle of iron, which was presumably used to reinforce the ends of the trunks. It is believed that the porousness of the material, the bad joints and the frequent bursts in cold weather resulted in much of the water escaping. After thirty years the wooden pipes were abandoned and newly invented cast-iron pipes substituted.—"The Stantonian."

Chromium-Molybdenum Cast Iron for Drawing and Forming Dies*

The use of cast iron in place of more expensive materials for certain drawing and forming dies has a number of advantages in addition to the low first-cost. For example, once a pattern is made up, duplicate dies (or future replacements) are readily produced and quickly available. Secondly, machining costs are held proportionally low, since the composition of the iron can be balanced to give a readily machinable structure. In the third place, the "self-lubricating" qualities of the graphite in the iron may be desirable to promote efficient production and satisfactory service life. Finally, when the iron is effectively alloyed, it will often develop sufficient strength in the as-cast condition. If, in addition, the iron responds readily to flame hardening, it may be selectively hardened at the edges and corners and other vulnerable spots where wear is likely to occur.

The advantages of flame hardening selected areas (where die wear is likely to be excessive) over conventional heat treating in a furnace and subsequent quenching need hardly be commented upon here. Obviously, flame hardening is adaptable to many castings where full hardening would be impracticable, if not impossible. Until recently, a disadvantage of flame hardening has been the problem of water quenching. Specialised equipment is sometimes necessary and the proper technique for each individual casting is not always easily acquired. It would undoubtedly simplify the problem of flame hardening for both the foundry and the purchaser if an analysis could be found that would flame harden satisfactorily on air cooling.

The Acme Foundry Company of Detroit has been marketing a chromium-molybdenum iron for some time under the trade name, "Hi-Tensilloy," that apparently meets the above requirements. This alloy iron tests 22 tons tensile strength regularly. Hardness on the test bar ranges from 223 to 241 Brinell as cast. Flame hardening (without a water quench) is said to meet a specification of 450 to 600 Brinell. Case depths extend up to $\frac{3}{32}$ in.

This iron may also be heat treated in the conventional manner. When heated to 840 deg. C., followed by an oil quench, a hardness of 550 Brinell or better at the surface of the 6-in. test block may be obtained.

This iron is available in two grades—Hi-Tensilloy "R" for dies and machinery castings not requiring flame hardening, and Hi-Tensilloy "F" that is recommended for draw dies and other castings requiring flame-hardening. A typical analysis suitable for flame hardening is given below:—T.C., 3.30; Si, 1.60; Mn, 0.80; S, 0.08; P, 0.18; Mo, 0.30 (minimum); and Cr, 0.50 per cent.

In this particular iron, the function of the molybdenum (and chromium) is, broadly speaking, to delay the transformation of the iron on cooling in the mould sufficiently to force the decomposition of austenite at a low temperature where relatively hard and strong transformation products are formed. Similarly, on flame hardening, say a large die section, the heat at the surface is conveyed away from the outside of the casting so rapidly (by the metal itself plus radiation) that transformation takes place at even lower temperatures. In this manner, the high surface hardness is obtained.

Microstructure

The microscope revealed that the lamellar pearlite was converted to a predominantly acicular structure by flame hardening. Moreover, the structure between the as-cast and flame-hardened zones had undergone a somewhat less drastic structural change. No pearlite or ferrite was in evidence in either of the flame hardened structures.

This condition illustrates the advantage of specifying carbide stabilising elements (like molybdenum and chromium) to prevent the structural breakdown which would take place in plain iron as the result of the drastic treatment to which the part is subjected during flame hardening. That is to say, during flame hardening a temperature gradient is set up from well above the critical point, at the surface of the metal, to room temperature (approximately) at the centre of the section. Somewhere along this temperature gradient there is a zone, just under the critical point, where graphitising tends to proceed at a maximum rate. In the case of unalloyed iron, extensive graphitisation may occur. In this case, the resulting structure would be essentially graphite and ferrite. Such a structure is weak, affording poor support for the hardened surface—support which is essential where the iron is to be used in presses where it will be subjected to very high pressures. Because molybdenum and chromium resist graphitisation, no such zone is encountered in the alloy irons.

Effect of Flame Hardening

As a rule, flame hardening causes no undesirable changes in the surface condition or shape of the part. No scale forms and, except for a slight discolouration, no visible changes are evident when the proper technique is employed. In thick, regular sections such as dies, there is no distortion to speak of and the iron is held at temperature for such a short period of time that growth is negligible.

Naturally, there are certain limitations that should be recognised when flame hardening is being considered, regardless of the composition selected. Abrupt section changes, for example, should be avoided. Variations in case depth will often follow changes in contour unless compensated for by the operator. If the surface is overheated for too long a time, checking may occur. Heavy sections are generally recommended where air-cooling is used. Sharp corners and short flanges on dies (that may cause scraping of the die walls) are to be avoided.

Flame hardening of cast iron is, in many respects, an art; it is most effectively utilised by founders and others who thoroughly understand the process and practise it regularly.

Flame hardened irons such as those described here are being cast-to-shape for large punches and dies with a variety of embossings and offsets. Two large motor car producers have adopted Acme Hi-Tensilloy for units of fender drawing dies. Another large motor company is using this chromium-molybdenum iron for radiator grille dies. This is also a drawing die. Movement of the metal quickly wears away an unalloyed die, requiring frequent spotting. During an entire model year, the chromium-molybdenum die was respotted only twice. It has shown little wear after producing 1½ million pieces.

The chromium-molybdenum iron described here, when properly flame hardened, is suitable for dies for motor car petrol tanks, refrigerator panels, stove and washing machine parts and similar major and minor stampings where a good wearing, flame hardened edge may greatly prolong die life. Moreover, when wear comes, the die can usually be flame annealed, machined, respotted and hardened (in position if necessary) to make it ready for another period of service.

* Extracted from matter published by the Climax Molybdenum Company.

War Damage Insurance

COVER FOR COAL AND COKE

Coal, coke, coal-tar, pitch and manufactured fuel of which coal or coke is the chief constituent, and a variety of metallurgical materials, are voluntarily insurable under the War Damage Act, 1941.

The business insurance scheme under Part II of the Act covers plant and machinery and business equipment, and came into force on April 17. The scheme is compulsory in cases where the value of plant, etc., covered is over £1,000; coal, coke, etc., are voluntarily insurable under this part of the scheme.

In order to be covered by the scheme it is necessary for insurances to be effected within 30 days. If any owner of plant, machinery or business equipment has not insured within the time allowed, he will not be covered, but anyone whose property is bombed within the period will be regarded as covered, provided he takes out a policy and pays the premium before the period has elapsed. The Act also provides for those cases in which the damage occurred before the scheme came into force.

Payment for claims will generally be deferred till after the war, and, in the meantime, interest will accrue at 2½ per cent. per annum.

For goods hitherto not insurable under the commodity insurance scheme of the War Risks Insurance Act, but now made voluntarily insurable by the War Risks (Commodity Insurance) (No. 2) Order, 1941 (S.R. & O., 1941, No. 491), the premium will be the same as that for goods which must be insured, namely, until June 2, 7s. 6d. per cent. Any change in the rate for the following quarter will be announced before that date. The goods which may be thus insured include bricks and tiles of brick-earth and clay and refractory bricks, blocks and tiles, other than glazed bricks and tiles; synthetic magnesite; lime; iron ore and iron pyrites; ores, concentrates, drosses and residues for smelting of aluminium, antimony, copper, lead, nickel and zinc (or spelter), and drosses and residues of tin, and aluminium, antimony, copper, lead, nickel, tin and zinc (or spelter), scrap and alloys; iron and steel scrap; cinder, scale and slag; and iron and steel of various descriptions, including iron castings (except where wholly or partly machined); steel castings; forgings, stampings (except where wholly or partly machined); cast-iron pipes and standard fittings therefor; malleable cast fittings for pipes and tubes; and assemblies of plates and sectional materials as component parts of structures. Also the following non-ferrous metals:—Copper, unwrought, whether refined or not; in ingots, bars, billets, wire bars, blocks, slabs, cakes cathodes, anodes and rods, and copper shot; aluminium, antimony, tin and zinc (or spelter), unwrought, in ingots, pigs, blocks, cakes, bars and slabs; lead and nickel, unwrought, in all forms; alloys of aluminium, antimony, copper, lead, nickel, tin, zinc (or spelter), unwrought, in ingots, pigs, blocks, cakes, bars and slabs; lead in white lead stacks and chambers.

Electrolytic Etching of Metal Sections

PROF. A. L. DE SY and H. HAEMERS, of the metallurgical and metallography laboratory at Ghent University, contribute a Paper to "Stahl und Eisen" giving details of a modified procedure for the electrolytic etch-polishing of metal sections. In his method, P. Jacquet affects electrolysis in a concentrated solution of glacial acetic acid and perchloric acid; this method has the advantage over mechanical polishing of avoiding a cold-worked surface layer and polishing scratches, while at the same time the delineation of inclusions is more carefully preserved. The authors have investigated means for accelerating the Jacquet test, and recommend a modified procedure of etch-polishing in a solution of perchloric acid and with ethyl alcohol denatured with ether in which the metal sample, after polishing with No. 2 to 0 emery cloth, is inserted as anode in a circuit of at least 110 volts. A polished section of steel can be obtained by this method in under 2 min., while aluminium and its alloys require only 3 min. The current density used depends on the nature of the metal treated. A final etch is recommended after electrolysis in the case of high-alloy steels, particularly stainless and rustless steels. The text contains 16 very fine reproductions of metal surfaces prepared by this method, the finer details being shown in sharp definition

Steel Castings in the Electrical Industry*

Steel castings for the electrical industry have to be made from a steel with a low percentage of impurities, yet fluid enough to be cast into the thinnest and most intricate shapes. Fifty years ago, when the electrical industry was in its earliest stages, the only processes for producing steel castings were the crucible, the Siemens Martin, and the Bessemer converter, all of which had limitations preventing their extensive use for the purpose outlined. The crucible process, while producing a suitable steel, was too costly and the output obtained was small. Eventually, however, the Tropenas converter process was installed at the Imperial Steel Works. It enabled castings, well nigh perfect in magnetic permeability, to be made to almost any design, and of a thinness of section unobtainable in any other steel process.

So far as the electrical industry is concerned, steel castings can conveniently be considered under four headings:—

(1) Those used for the static members of electrical machines, where good magnetic permeability is very often of greater importance than mere mechanical strength, *e.g.*, the field frames of D.C. motors and generators.

(2) Those used for certain flux-carrying members of machines where magnetic permeability must also be associated with good mechanical properties by reason of stresses imposed; for example, by the action of centrifugal force on rotating field systems, or by external forces, such as those operating on the shells of traction motors in service.

(3) Those used for such components of machines as demand high magnetic strength, but where permeability is unimportant, *e.g.*, non-flux-carrying members like the spiders of rotors, flywheels, pedestal bearing brackets, etc.

(4) Those parts which should be prevented from carrying magnetic flux, *e.g.*, end-bells of turbo alternator rotors, and certain switchgear components. Such castings may be classified as non-magnetic.

Requirements for Electrical Castings

In general, steel castings for electrical use have to conform to definite standards laid down in appropriate specifications. Those enumerated under (1) above must possess high permeability, homogeneity of composition throughout, uniform heat-treatment, and good machinability. Group 2 comprises castings to be used for magnet poles and magnet wheels. These must be of sound steel, in the production of which it is required that special attention shall be paid to the method of teeming, and the disposition of runners, risers and vents in order to ensure homogeneity. After being machined, they must be satisfactorily balanced, both statically and dynamically. The castings must be in all respects sound and free from blow-holes, slag inclusions, etc. In addition, it is usual to specify the manganese, silicon, sulphur and phosphorus contents.

The carbon content may be varied with the manganese content to give the required physical properties. The carbon and manganese contents range respectively between 0.15 and 0.30 per cent., and 0.60 and 1.20 per cent., according to requirements. Certain types of magnet wheels without holes are on occasion required in dynamo magnet steel, *i.e.*, carbon and manganese 0.10 per cent. respectively. Others have carbon 0.16 to 0.20 and manganese 0.65 and 0.75 per cent.

As regards heat-treatment, very careful and thorough annealing is necessary, so that the "as cast" structure shall be completely transformed. The physical properties are determined by tests of tensile strength, yield point, elongation, Brinell hardness and permeability, while the casting dimensions must conform to specification.

Group 3 covers steel castings for general purposes. These must conform to B.S.S. 592-1935, 28-ton grade. Castings of this type are not used for magnet frames, magnet poles or magnet steels. The physical properties required cover tensile strength, yield point, elongation, and, in addition, a cold bending test.

The non-magnetic castings, as well, of course, as all others included in Group 4 above, must be free from defects, such as cracks, blow-holes, scale, etc. They must also possess reasonable machining properties, and must not exceed a definite permeability value. The physical properties required include hardness, tensile strength, yield point, reduction of area, elongation, and the application of the Izod impact test.

* Extracted from "The Edgar Allen News."

Automatic Control of Arc Furnaces

The marked fluctuations of resistance in arc furnaces during melting periods reduce the efficiency of the furnace, increase the power consumption and react adversely on the supply mains. Discussing the question of automatic control of these furnaces in the light of economic and efficient operation, A. CLERGEOT, in "Revue générale élect," writes that control can be realised *via* the electrodes or the furnace voltage. Adjustment of the electrodes, and hence control of the arc resistance, is usually achieved by electric motors and pulley gear or hydraulically, the controlling magnitude being the electrode current, which must be kept constant. Hydraulic control has the advantage of simple design, higher controlling forces and more rapid displacement of the electrodes, while the electric method avoids the use of water with its contingent difficulties.

The simplest electrical method utilises a reversing relay responding to deviations in the electrode current from normal. In the Thury controller, oil damping is employed to avoid decremental oscillations due to over-regulation, while in more modern types of controller the rate of adjustment is made proportional to deviations in the electrode current. In one type a separate generator with counter-circuited exciter windings is used, one winding receiving constant excitation and the other a variable excitation corresponding to variations in the electrode current, using either a Tirrill regulator or a rectifier circuit. In other methods of control, the potential difference between the electrodes and the furnace hearth is used for master control.

Hydraulic methods of control usually contain some electrical element or other for an intermediate regulating operation, *e.g.*, the Cuénod controller has a servo-motor controlled by a current relay to operate the hydraulic valve gear, a lever system varying the speed of the servo-motor in relation to the potential difference between the electrode and the hearth, as well as the approach of the current to the rated value. The Arca controller has a magnet controlled by the electrode current, this magnet actuating a valve in the intermediate hydraulic system. No intermediate hydraulic components are used in another controller equipped with a three-phase motor with an auxiliary phase as relay, which is fed with electrode current through a powerful current transformer, the motor relay directly actuating the hydraulic valves. An Italian design of controller operates on similar lines.

Core-Drying Shells

THEIR NECESSARY USE DURING WARTIME

By JAMES M. NIVEN.

With the ever-increasing introduction of female labour into the wartime factories, it is essential that suitable plant and devices be employed to curtail the possibility of wasted labour and ensure the maximum production of any work on which women are employed. The writer would therefore like to draw attention to the beneficial use of core-drying shells to replace, especially on small cores, the old-fashioned and less accurate method of "bedding out" in sand.

It has been a personal experience, in various foundries, to find that a "bedded out" core is more likely to be distorted than one which is dried in a shell, and, if the core be of complicated design, the degree of distortion may not be discovered until the casting is being checked and some thickness found to be wrong.

The usual procedure in bedding out a core after the core-box is rammed up is to remove one-half of the core-box, place a wooden or metal frame around the core, pack this with sand, strike off level with the top of the frame, turn over, remove corebox, and finally lift off the frame, and the core is ready for the drying oven.

Now, on looking round the corebench where the writer is employed, what does he find? Two things come immediately to his attention. First, the frames are not tapered on the inside, with the result that the "bedding" is generally disturbed on the removal of the frame, and the core has lost its proper seating.

Secondly, the sand which is used for "bedding-out" purposes is generally old sand mixed with some water to give it bond, and it is quite often on the dry side when used, so that it will not stick to the core. This is where the mistake is made.

Oil sand is a fairly heavy sand when in the green state, and a core must have as support a seating, the strength of which is greater than the weight of the core itself; otherwise distortion can only be expected. A personal view is that the use of shell driers is the best answer to the not too dependable "bedding-out" method.

Almost any core lends itself to this method, and not only is accuracy guaranteed, but speed in production is considerably increased, and female labour can be employed with the minimum of supervision.

The extra expense in providing these shells is more than recovered when every item of production is considered. For the benefit of those readers who have not employed this method—and there still are some, for every foundry in the country is not a modern one—the following simple details are submitted:—

The corebox should preferably be a metal one,* and the essentially metal shell for drying is made from, in most cases, the least complicated half, so that, when half of the corebox is removed, the shell takes its place, the corebox turned over, and the other half removed, leaving the core lying in the shell and ready for drying. The quantity of these shells required is determined by the number off the particular job and the speed of drying in the core oven.

In conclusion, it is urged that, although the author is not even a charge hand, each foreman and manager should contact his men and strive to maintain, through co-operation, the highest degree of production in their work, and the quality of the goods they produce will automatically rise. This is essential in wartime, when only the best is good enough and waste is criminal.

* Other refractory materials are equally effective, especially in the form of plain plates—[EDITOR].

Vitreous Enamelling Section

Observations on Cast-Iron Enamelling*

By A. BIDDULPH

This Paper outlines a few points that may be of mutual interest to the foundryman and the enameller, especially the wet-process enameller. The latter is stressed because, whereas in the case of the dry process the enameller and foundryman work very closely together, usually under one management, in the case of the wet process the designing, casting and enamelling are often carried through by separate establishments.

It is not intended to put forward any particular composition of metal for castings, as no two enamellers would agree to any specific analysis, and many different analyses give good results in practice. Composition of itself is not the only criterion, as moulding sand, facings, gating, pouring and iron temperature all have an effect on the suitability of the casting as a base for enamel. Especially in the case of baths and sanitary ware, the foundry manager is usually responsible for the details of pattern design, for running the foundry, and often for the enamelling of the ware. Because of this responsibility for producing the finished bath, the foundryman makes whatever modifications are necessary to the design and moulding practice to ensure the successful finishing of the product. Chemical compositions are worked out to suit local conditions, and modified to suit variations in pig-iron supplies.

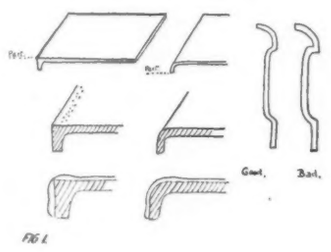


FIG. 1.

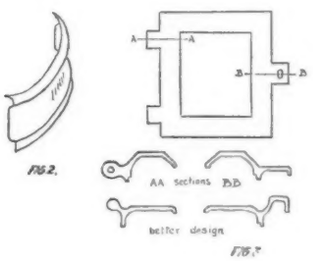


FIG. 2.

In some cases a similar control of the design, casting and enamelling of cookers is maintained, with very gratifying results in first-class finish and low reject figures, but in the majority of cases the enameller is expected to apply enamel to castings which may have been well designed and made for a fine cast finish, but which are not the ideal bases for enamel.

Enamel, as a finished surface for all kinds of domestic apparatus, is becoming more and more popular, and is being applied to sheet-steel products as well as to cast iron. Wherever cast iron is used in gas and electric cookers, electric fires, scales, anthracite stoves, grates, ranges and mantels, and many other products of the light castings industry, its continued sale as part of these articles in face of competition from sheet steel will depend partly on the ability of the founder to give the enameller a consistently sound casting which can be depended upon to enamel satisfactorily.

* Paper read before a joint meeting of the Falkirk Section of the Institute of British Foundrymen and the Scottish Section of the Institute of Vitreous Enamellers. Mr. Alex Cunningham presiding.

A Changed Outlook

Even to-day, despite much development work during the past ten years, many articles of cast iron that are sold with an enamelled finish are designed on principles that applied to the fine-cast finish. Twenty years ago or more, the ironfounder depended for sales' appeal upon shape or form, *e.g.*, straight lines, sharp corners, applied decorations that could be produced from the pattern. Much fine work was produced under these conditions. Sharp corners suggested a clean-cut design, heavy hinges and door latches indicated massive strength, while scrolls, corrugations and foliage added to the "artiness" of many products.

This was a good practice when there was only the black finish, and the black-lead brush was used by every housewife. To-day the call is for labour-saving design and for bright permanent colour, such as only enamel can supply, and sales' appeal is now dependent upon colour as well as on form. Sharp corners are no longer an advantage, scrolls and other embellishments distract from, rather than enhance, the lines of smooth design, and the suggestion of massive strength is no longer desirable. Now that enamel is so generally used for cleanliness, protection, durability and appearance, but mainly the latter, the casting should be designed so that the enamel can be shown to the best advantage, and all sharp edges should be rounded off and "applied decorations" eliminated.

The Newer Technique

No matter how well the applied decorations may look in the fine cast condition, the enamel will obscure the detail, and the effectiveness of the decoration will be lost. The same applies to sharp edges, but in this case not only will the effectiveness of the sharp lines be lost, but the sharpness of the edges is bad for enamelling. Even if with very great care an even coating could be applied over a sharp edge, when the enamel is semi-fluid during firing, it will tend to run away from the edge, leaving such a thin film of enamel that the iron shows through as a black edge.

In assembly of castings it is inevitable that they will be knocked together. Enamel on a flat or round surface will withstand considerable ill-use without chipping, but on a sharp corner even a light blow will be equivalent to knocking with a sharp chisel. Examples of this are shown in Figs. 1 and 2.

In addition to outward appearance, considerable improvements can be made in the manner in which castings are assembled. Where the unit was originally designed for black finish and was a good fit, then allowance must be made for thickness of enamel wherever two adjacent surfaces are enamelled. Direct enamel to enamel contact should be avoided, and fitting strips incorporated in the pattern to allow for adjustments during assembly.

Blistering

Blistering is the most important of the enamellers' difficulties with cast iron, and much can be done by the foundryman to help in its elimination. Blistering is of two kinds: (1) General blistering over the whole surface, and (2) localised blistering that may cover five per cent. or less of the enamel surface.

General blistering is not common. It may occur if a sheet-iron enamel is used on a casting, or if the casting is greasy or dirty, or if blasting has been omitted; but these causes are accidental and not usual. One cause of general blistering that is beyond the enameller, and has been encountered, is when a large proportion of steel scrap has found its way into the cupola. This was certainly a case where the product of the cupola was at fault, and is an exception to the general rule that any iron that will make a sound casting can be enamelled.

General blistering is so unusual that the enameller looks in his own shop for the cause, and generally finds it, but localised blistering is quite another matter and is often experienced, especially in jobbing shops where all kinds and conditions of castings are received to be enamelled. Customers invariably expect 144 good castings for every gross sent. Some cases of localised blistering have been traced to parts insufficiently blasted, but generally it may be said that localised blistering coincides with a variation in the iron base, usually due to change of section thickness. It will be found to be repeated in the same places on similar castings, though it may not be bad on every one.

Fundamental Causes of Blistering

The fundamental cause of blistering of cast-iron enamels has been the subject of many discussions, and several theories have been evolved to account for the phenomenon. It is usually held that blisters are due to the evolution of gases around the temperature of firing enamels, CO and CO_2 being the gases most often indicated, although the recent work of Zapffe and Sims suggests that hydrogen also plays a part in the mechanism of blistering. Krynitsky and Harrison hold that blistering is caused by the micro-chill that occurs in all grey iron castings, forming cementite which later breaks down under heat-treatment to a very fine graphite, similar to temper carbon. This is more readily oxidised than ordinary graphite, and causes evolution of CO and CO_2 which may continue up to the full firing time of the enamel. If the evolution is finished before the enamel is fully fired then there is a good chance of the blisters healing over.

In support of this is the widely-held opinion that annealing helps to prevent blistering, and thorough blasting to remove the surface layer of iron is now standard practice. Other workers hold that the evidence for micro-chill is only circumstantial, and other causes have been suggested, including gas absorption at the

time of pouring, dirt inclusions, uneven thickness, and porosity in the metal.

Micro-chill may explain something of the causes of general blistering over the whole surface of a casting, but, as has already been said, this type of blistering is not common to-day. It is likely, however, that as general blistering is found when blasting has been omitted there may be considerable truth in this theory. Micro-chill, however, explains nothing of localised blistering, which is the real difficulty. If the whole surface has been blasted and there are no blisters at all on 95 per cent. of the surface, then the micro-chill and its effects will have been eliminated.

Dirt inclusions are one common source of localised blistering and can sometimes be found indicating the wash from the runners. This is a case where better skimming of the iron in the hand ladle and a more gentle pouring will prevent a lot of blisters and blowholes. An instance has been known where two men on the same floor were making similar castings. Those from one man gave no trouble, yet from the other man most castings showed blisters and blowholes near to the runners. Such dirt inclusions, however, are indicated by holes in the casting, usually visible after blasting, and the harmful effects may be modified by extra blasting, and filling of the exposed holes with a good enamel filler.

Uneven thickness and porosity are the real cause of most localised blistering, which usually coincides with lugs and heavy ribs on the back of the casting or with a heavy boss or mass of metal placed there for "strengthening." There is always the tendency for such a casting to develop porosity in the face side, coincident with these lugs, etc., owing to the slower cooling of the greater mass of metal. This porous iron is not air-tight, and the very porosity indicates a large surface area exposed to air and subject to oxidation while the casting cools in the mould, and, after annealing, preparatory to blasting. Then when the casting is heated for fusing the enamel at temperatures above 650 deg. C. there is considerable oxidation of carbon among the porous iron, with evolution of CO and CO_2 at sufficient pressure to cause blisters. This evolution of gas continues for some little time after the enamel is withdrawn from the furnace, and until it is no longer fluid enough to heal over a burst blister. Such of the gas as may have been absorbed by the hot iron will also be expelled as the iron cools, thus adding to the blister-making effect. This theory is supported by several known instances, where an enamelled casting has been observed to boil badly in certain heavy spots as it cooled from firing temperature to about 600 deg. C.

Influence of Design

In view of what has been said about porosity and micro-chill, it may be of interest to mention an investigation carried through in production some little while ago. A casting of a general thickness of about $\frac{1}{4}$ in. had three heavy sections about 1 in. thick, which nearly always showed some blistering (Fig. 3). Attempts were made to effect a cure—extra blasting on the affected parts, annealing at higher and lower temperatures for varying periods, etc., and though at times there was some improvement, it was not maintained. As it was observed that there was no blistering on the thin sections (except sometimes in the proximity of the runners), and that these were the quickest to cool in the mould, it was thought that if the heavy section could be lightened the blisters would be cured. This was done, but proved of no avail, for blisters persisted, probably due to the fact that there was still too heavier a section of metal present.

A further attempt was made to get an iron structure over the heavy section similar to that on the light section by chilling the iron at the three heavy points. This was done by the use of rock sand, and the results were surprisingly good. The surface was, indeed, rather rough, and occasionally a file was necessary to remove high spots, but usually the roughness was no more than would be covered by a normal thickness of enamel.

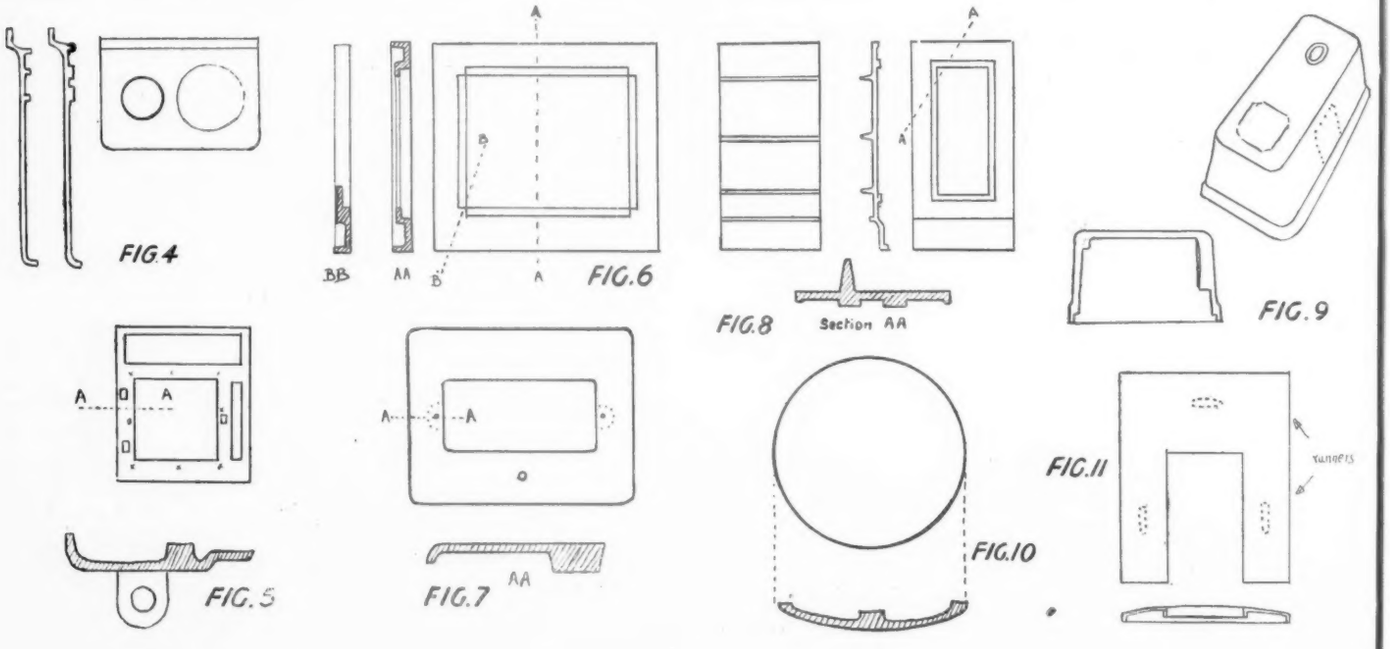
Many of the lugs and heavy ribs at present cast on the back of enamelling castings are far heavier than is necessary. The old idea of massive strength persists, but should be modified. Lugs should be just strong enough to do their job with a reasonable factor of safety. Anything beyond this is a waste of iron and a source of trouble in enamelling. Hence it detracts from the saleability of the casting. How design can be improved is shown in Figs. 4 to 11.

Blasting of Castings

This is a very important part of the enamelling process, especially with liquid enamel. Under favourable conditions it is possible to enamel a casting without cleaning the surface, but for quantity production with durable enamels, thorough blasting is essential. Automatic blasting machines now include the centrifugal slinger as well as the pressure type, and in each of these a great deal of experiment has resulted in tremendous increases in output. There are quite a number of enamelling shops, however, where manually operated blasting is still applied, and, indeed, even where automatic machines are in use, the edges of the ware have often to be finished by hand. It is in the hand-blasting cabinets that there is most room for improvement both in efficiency and cheapness.

Maximum efficiency of blasting operations depends upon several factors, amongst which are:—(1) *Abrasive* (silica sand or chilled iron; size and mixture); (2) *air supply* (pressure; water content); (3) *nozzle* (shape; bore; material), and (4) *nozzle manipulation* (distance and angle of cut).

(To be continued.)



Acid Resistance of Enamels

The time function of the acid resistance of enamels is examined by G. SCHMIDT in "Chemische Fabrik" in order to arrive at a method for measuring the acid resistance, so that the results of short-period measurements may be employed for deducing the probable behaviour of enamel on protracted exposure to acid attack. The time-resistance law may be expressed, according to the author, by the equation $x = a.n\ (1 + c.t)$ where x is the quantity extracted in time t expressed in terms of unit surface, a and c are constants, the former being related to solution pressure and the latter a reciprocal resistance to acid attack. Over long solution periods, a is proportional to the gradient of the solution curves, such gradient being inversely proportional to the acid resistance of an enamel. a is thus a measure of the acid resistance; the smaller the value of a, the greater the acid resistance. Application of this relationship shows that an enamel is stable towards a certain acid if an a value less than 0.4 mg. per sq. cm. is calculated from loss of weight determinations on treatment with the boiling acid in question. An enamel has a high acid resistance if the a value calculated is less than 0.4 mg. per sq. cm. when determining the loss of weight with boiling 20 per cent. HCl.

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PIG IRON

IS CHARACTERISED by closeness of grain structure, uniformity of composition and fine graphitic carbon evenly distributed.

IS PRODUCED to guaranteed analysis in seven standard grades.

CAN BE MADE to customers' individual requirements with total carbon from 2·6 per cent. upwards.

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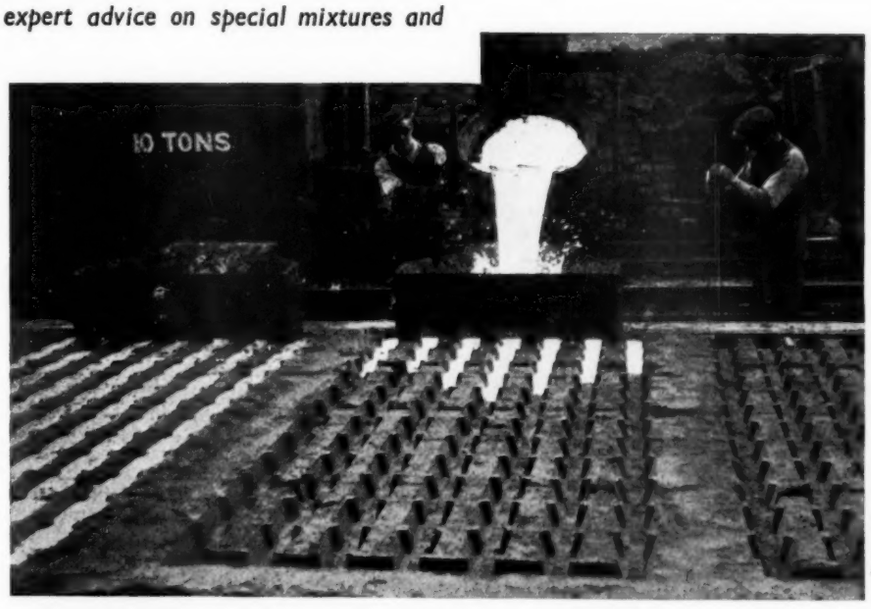
Users are invited to avail themselves of the Stanton Technical Service which offers free expert advice on special mixtures and other Foundry problems.



THE STANTON IRONWORKS COMPANY LIMITED, NEAR NOTTINGHAM

An Open-Air Art Gallery

PORCELAIN ENAMEL PICTURES EXHIBITED

This Spring thirty-eight paintings in porcelain enamel on steel, copied from the finest examples of religious art through the centuries, will be placed in a sunken garden at Sunset Memorial Park at Cleveland, Ohio.

Daniel Boza, Cleveland artist, has already completed twelve 32 by 42-in. panels in porcelain enamel upon which he has copied with ceramic colours the well-known religious paintings of such artists as Botticelli, Millet, Raphael, Watts, and Rembrandt. Including gilded porcelain enamelled frames, the overall dimensions will be 44 by 54 in. These subjects, as well as the remaining ones, were selected by Dr. Arthur J. Culler, Pastor of Heights Christian Church, Cleveland, Ohio, after a careful study of the religious paintings of medieval and modern artists.

Feeling that a cemetery should be something more than a collection of headstones and monuments, those responsible for Sunset Memorial Park have sought ways and means of beautifying the grounds. One suggestion of Dr. Culler, art consultant for the project, was the erection of reproductions of well-known religious paintings to provide an atmosphere more consoling than surrounding grave-stones. He and other interested parties had visited the New York World's Fair, had seen the several porcelain enamelled murals of Daniel Boza and J. Scott Williams, and supplied by the Ferro Enamel Corporation and Porcelain Metals, Inc., of Long Island City, New York, and felt that it might be possible to reproduce the paintings they wanted to use in the cemetery in this new medium with its permanence, non-fading of colour, and resistance to the action of weather.

It was decided to place the reproductions in a large sunken garden which is to serve as a focal-point in the cemetery. Running through the centre of this six-hundred-foot-long garden, a variegated coloured stone path has thirty-six side-paths at right angles leading to individual paintings in this outdoor art gallery. Midway the walk will encircle a fountain 20 ft. in diameter. The fountain itself is to be a reproduction of the famous "Boy With a Duck" done in porcelain enamel. The water will be caught in a basin of sky-blue porcelain enamel 8 ft. in diameter. The basin will be supported by a fluted spiral column also finished in porcelain enamel.

Daniel Boza was selected to execute the necessary art work in porcelain enamel. The large 12½-ft. by 17½-ft. porcelain enamel mural exhibited in the Ferro Enamel Corporation's stand at the New York World's Fair in 1939, as well as the large map of the world on the side of the Y.M.C.A. building at the Fair, were executed by Mr. Boza in porcelain enamel on steel. He also has a large number of other paintings in porcelain enamel to his credit.

The necessary porcelain enamelled steel panels and frames are being fabricated and enamelled at Ellwood City, Pennsylvania, by the Beaver Enamelling Company. Working in collaboration with the artist, the Beaver Enamelling Company has helped solve design problems. All panels and frames are being fired hanging in a high side-wall furnace.

Using a special mixture of oils and ceramic colour oxides as covered by the patent assigned to Bomat, Inc., the artist applies his colours to the white porcelain enamelled panels in much the same way he would apply regular oil colours to canvas. The same flexibility, the same delicacy or boldness of stroke, the same blending of colours are all as possible on porcelain with this method as with ordinary paints on canvas.

After painting the complete picture, using in some cases practically every colour on the artist's palette, the panels are thoroughly dried and then fired. Only the one fire is necessary, although if retouching is required, an extra firing can be given the panel without affecting it.

One interesting point which has been noticed already in the case of the murals completed and in use is the fineness of detail possible in this medium, yet such fineness of detail seems to be discernible at greater distances than would be possible with the same detail in oil colours on canvas. This probably can be attributed to the much better light-reflection values of the porcelain enamelled surfaces.

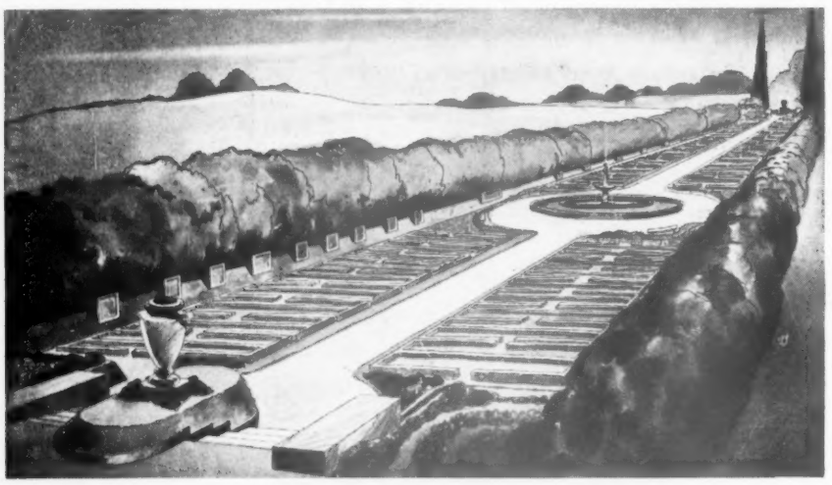
The frames for the pictures are fabricated from enamelling iron and porcelain enamelled in black. Then a coating of liquid gold is applied and fired, resulting in a "gilded" frame which sets off the pictures very well.

Over this coat of liquid gold, as well as over the entire surface of the enamelled paintings, a thin coating of a clear acid-resisting overglaze enamel will be applied to ensure the weather-resistance of the finish.

Cast bronze plaques with the title of the picture and the name of the original artist will be fastened to each picture frame. The entire picture will then be mounted on steel supports anchored in concrete. These supports will be anchored several feet behind the picture, and will arch over to support the picture with practically invisible supports. Shrubs and trees in front and around the pictures will completely hide the supports and will provide a natural framing that will enhance the gold of the frames and the brilliance of the enamelled painted surfaces of the pictures.

On opposite sides of the porcelain enamelled fountain in the centre of the garden, two larger porcelain enamelled paintings 60 by 84 in. will be placed. These will depict the "Last Supper" after Leonardo da Vinci and the "Creation of Adam" after Michelangelo.

This outdoor art gallery will again prove the value of porcelain enamel as a weather-resisting material. Like the porcelain enamelled murals exhibited at the New York World's Fair for two years, they will again demonstrate the possibilities of colour and design in porcelain for outdoor and exterior use.



Artists Sketch of the Sunset Memorial Park, Cleveland, Ohio, Embellished with Pictures Carved Out of Vitreous Enamel.

High-Duty Cast Irons for General Engineering Purposes

Dr. H. J. Gough, M.B.E., F.R.S. (Member of Council), resigned his Chairmanship of the Committee of the Institution of Mechanical Engineers on the grounds of his official commitments, and Prof. A. L. Mellanby, D.Sc., LL.D., Hon.M.I.Mech.E., has been appointed in his place. The work of the Committee has continued at the British Cast Iron Research Association under the supervision of Mr. J. G. Pearce, M.Sc., M.I.Mech.E. (reporter).

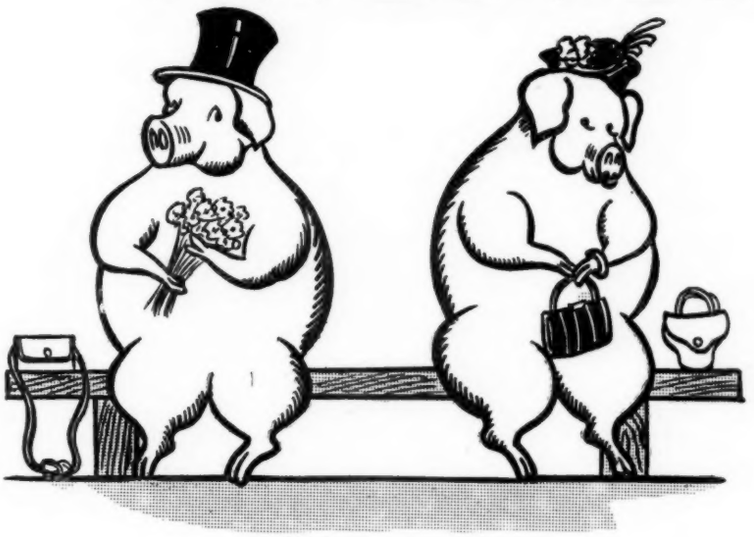
During the year that section of the Committee's programme concerned with alloyed high-duty irons has been completed.

The war has brought about a considerable change in the situation relating to high-duty cast irons, and in many directions they have been applied to engineering products to relieve the pressure on the production of both steel and non-ferrous metals. In this work the First Report of the Committee has been of great assistance, and has been extensively used by Government departments, the Services and other authorities. The situation, however, is also considerably affected by the raw materials supply, and in particular by the necessity for conserving hematite and low phosphoric iron supplies for steel manufacture and of avoiding the import of these materials as far as practicable. This necessitates the use of home resources in pig-iron to the greatest possible extent and therefore the use of phosphoric pig-irons. The Committee agreed that the programme should be modified to include the study of phosphoric high-duty irons, the first report on which is also in draft form. The data will form the Committee's Second Report, which it is hoped to publish shortly. The Ministry of Supply and the Iron and Steel Control regard the work of extending the use of phosphoric irons under present conditions as of national importance.

In order that information might be available in convenient form to engineers on various types of high-duty and special-duty irons, the preparation of monographs on the engineering properties of various classes of these materials is envisaged, and the austenitic cast irons will form the subject of the first of these.

W

Delayed ... ...Action



We are not naturally shy of proposals to use "Warner" Pig Iron, but in the present circumstances, when we cannot always maintain our reputation for prompt despatch, we ask for notice of your intentions as early as possible.

Procrastination is almost as dangerous in individuals as in bombs, so far as war-time production is concerned. Anticipation of your requirements will help us to fulfil them to our mutual satisfaction.

Warner's

Special Pig Irons

WARNER AND CO. LTD., CARGO FLEET, MIDDLESBROUGH

W

The Week's News in Brief

Trade Talk

R. A. LISTER & COMPANY, LIMITED, of Dursley, Glos, have sent a donation of £500 to the Lord Mayor's National Air-Raid Distress Fund.

THE BROKEN HILL PROPRIETARY COMPANY, LIMITED, is paying on May 28 a half-yearly dividend of 9d. (Australia) per share, or 3¼ per cent.

THE UNION STEEL CORPORATION OF SOUTH AFRICA, LIMITED, has sent to the Minister of Aircraft Production the sum of £6,300 for the purchase of a "Spitfire."

IRISH STEEL, LIMITED.—At a meeting of Cork Harbour Commissioners this week a letter was read from Mr. Vincent Crowley auditor, Dublin, intimating that he had been appointed receiver by the trustees for the debenture holders over the assets of Irish Steel, Limited.

AT THE END OF 1940, the United States had under construction or had made appropriations for the following naval tonnage: 17 battleships, 12 aircraft carriers, 54 cruisers, 205 destroyers, 41 submarines, 9 seaplane tenders, 5 submarine tenders, 1 minelayer, 5 minesweepers, and 8 motor torpedo boats. The "Iron Age" estimates that this would call for 1,118,600 tons of plain steel.

TWO HUNDRED employees at the Allied Ironfounders (Ireland), Limited, Waterford, have gone on strike following the expiration of notice served on the directors by the men's representatives. A few workers who reported for duty as usual were sent home by the management. The dispute has arisen over wages and conditions generally. A last-minute effort by the Mayor of Waterford to avert a stoppage proved abortive.

THE NET PROFIT of the Steel Company of Canada, Limited, for 1940 was $4,264,384 (against $4,686,680 for 1939), equal to $5.92 a share on the combined issued preference and ordinary shares. Besides the quarterly dividends aggregating $1.75 a share paid on the ordinary shares an additional dividend of $2 was paid last February, thereby equalising the dividends hitherto paid on the ordinary and preference shares of the company.

AN ADDITIONAL annual saving of from 30,000 to 40,000 tons of tinplate is expected to result from the extension of the restrictions placed on the use of uneconomic and non-essential tinplate containers under a new Order, made by the Minister of Supply, which came into force on Monday, April 28. The Order (the Control of Tins and Cans (No. 4) Order, 1941), which cancels the three previous Orders, prohibits the use of tinplate for packing some 30 additional commodities.

Personal

MR. T. GIBSON, secretary of the Iron and Steel Control, has been appointed a director of the British Iron and Steel Corporation.

MR. JAMES HOPWOOD, J.P., M.I.Mech.E., has been appointed chairman and managing director of Adams-Hydraulics, Limited, York, and Mr. Stanley Thompson has been appointed a director.

MR. M. H. ROLLASON has succeeded his brother, Mr. Neville H. Rollason, as managing director of the Shelton Iron, Steel & Coal Company, Limited, on the latter's appointment as managing director of the United Steel Companies, Limited. Mr. N. H. Rollason retains his seat on the board of directors of the Shelton Company.

THE ELECTION of Mr. Fred C. Stewart, one of Scotland's most prominent men, as president of the Institution of Engineers and Shipbuilders in Scotland is announced. Mr. Stewart has had extensive experience in a wide range of the engineering industry, and his companies employ thousands of workers engaged on Government contracts. Amongst the many firms with which Mr. Stewart is concerned are Thermotank, Limited, and Kelvin, Bottomley & Baird, Limited, of Glasgow. The Institution's new vice-presidents are Dr. Andrew M'Cance, director of Colvilles, Limited, and Sir Stephen Pigott, managing director of John Brown & Company, Limited, at Clydebank.

Obituary

MR. OSWALD SOLON, formerly London representative of Alley & MacLellan, Limited, has died at Worcester.

MR. SAMUEL ERNEST CHESTERMAN, managing director and secretary of James Chesterman & Company, Limited, Sheffield, tool makers, etc., died recently. He was the son of the late Mr. William Chesterman, J.P., who was a Master Cutler.

MR. ROBERT MORRISON MACDONALD, a partner in the firm of Geo. Rae Anderson, iron and steel merchants, of Liverpool, died recently at Hoylake, aged 79. He had been associated with the firm for over 60 years and was one of the oldest active business men in Liverpool. During the last war Mr. Macdonald held an official position in connection with the distribution of iron and steel.

LIEUT.-COMMANDER GEOFFREY HENEAGE DRUMMOND, V.C., R.N.V.R., for many years a member of the staff of Imperial Chemical Industries, Limited, died last week at the age of 55. Lieut.-Commander Drummond was awarded the Victoria Cross for conspicuous gallantry during the second raid on Ostend, which took place on the night of May 9-10, in 1918. He was in command of Motor Launch 254, which rescued the crew of the "Vindictive."

Reports and Dividends

Broom & Wade, Limited—Interim dividend of 7½ per cent. (same).

Hopkinsons, Limited—Final dividend on the ordinary shares of 10 per cent., making 15 per cent. (same).

Quirk, Barton & Company, Limited—Profit for 1940, before tax, £10,821 (£12,670); final dividend of 6 per cent., making 8½ per cent. (unchanged).

Churchill Machine Tool Company, Limited—Net profit for 1940, after income-tax, E.P.T., depreciation and reserves, £65,604 (£85,507); dividend of 30 per cent. (same).

C. Akrill & Company, Limited—Profit for 1940, £9,517; preference dividend, £719; dividend of 3s. (same) a share; to taxation, £3,000; to special development reserve, £1,000; employees' fund, £1,000; carried forward, £17,942.

C. & W. Walker, Limited—Profit for the year ended January 31, £14,288; brought in, £12,309; dividend on the preference shares of 7½ per cent., £3,000; dividend on the ordinary shares of 10 per cent., £9,530; carried forward, £14,067.

Engineers & Ironfounders, Limited—Profit for 1940, £6,667; brought in, £10,175; dividend on the 7 per cent. cumulative preference shares, £1,805; interim dividend of 2½ per cent. on the ordinary shares, £403; final dividend of 7½ per cent., £1,112; bonus of 1s. a share, £741; carried forward, £12,780.

W. Canning & Company, Limited—Profit for 1940, after providing for taxation and depreciation, £55,172; brought in, £38,534; general reserve, £5,000; contingency reserve, £15,929; interim dividend on the ordinary shares of 5 per cent., £8,625; final dividend of 5 per cent., £7,500; bonus of 2s. per share, £15,000; to employees' benevolent fund, £3,000; carried forward, £38,653.

Craven Bros. (Manchester), Limited—Trading profit for 1940, £182,620 (£187,621); interest charges, £6,564 (£1,035); war risks insurance, £6,244 (£2,503); A.R.P., £1,800 (£6,379); depreciation reserve, £15,000 (same); provision for taxes, £80,000 (£56,375); net profit, £73,012 (£106,329); interim dividend of 4 per cent. (7½ per cent.), £12,000 (£22,500); final dividend of 10 per cent. (15 per cent.), £30,000 (£45,000); carried forward, £126,359 (£97,147).

Contract Open

Kanturk, May 24—Supply and installation of mechanical equipment, electric motors and pumps, etc., for North Cork Board of Health and Public Assistance. Mr. D. C. Murphy, secretary, County Hospital, Mallow. (Fee £20, returnable.)

New Companies

(From the Register compiled by Jordan & Sons, Limited, Company Registration Agents, 116 to 118 Chancery Lane, London, W.C.2.)

D. H. Die Casting Company, Limited—Capital, £4,000. Directors: C. A. and P. Honen, "Fairmead," Fairlight Avenue, Windsor, Berks.

G. Clancey, Limited, 61, New Street, West Bromwich—Capital, £2,000. Ferrous and non-ferrous founders, etc. Directors: G. and A. E. Clancey.

John Le Boutillier (1941), Limited—Capital, £20,000. Ironmasters, etc. Directors: P. H. Cheston, 20, Northwick Circle, Kenton; A. J. Foster and J. Jutte.

R. E. Morley & Company, Limited, 1, Chancery Place, Manchester—Capital, £1,000. Engineers and founders, etc. Directors: R. E. Morley and J. Maxwell.

Thames Valley Pattern Works, Limited, 26, Elm Tree Road, Teddington, Middlesex—Capital, £2,000. Directors: W. A. H., H. A., and E. W. Williams, and G. Lambert.

G. Potter & Sons, Limited, Western Road, Leicester—Capital, £20,000. Iron and brass founders, constructional engineers, etc. Directors: J. Nurse; A., W. C., and G. H. Potter.

A. W. Gower & Son, Limited, Green Bridge Works, Stafford—Capital, £15,000. To take over the business of an agricultural engineer, etc., carried on at Britannia Foundry, Market Drayton, by C. B. Etches. Directors: C. B. Etches and H. F. and W. D. Burgess.

Applications for Trade Marks

The following list of applications to register trade marks has been taken from the "Trade Marks Journal":—

"CARRIER"—Furnaces, kilns, etc. CARRIER ENGINEERING COMPANY, LIMITED, 24, Buckingham Gate, London, S.W.1.

"TUNGSIT"—Hard common metals. TUNGSIT ELECTRO-METAL WORKS, LIMITED, 46, Southampton Row, London, W.C.1.

"POWMET" and "METPOW"—Metals and alloys. POWDER METALLURGY (1940), LIMITED, 101, Leadenhall Street, London. E.C.3.

"NIMONIC"—Nickel bars, sheets, rods, wire, etc. HENRY WIGGIN & COMPANY, LIMITED, Thames House, Millbank, London, S.W.1.

"HIDUMINIUM"—Aeroplane, land vehicle and cycle frames, etc. HIGH DUTY ALLOYS, LIMITED, 89, Buckingham Avenue, Trading Estate, Slough, Bucks.

"MAGNUMINIUM"—Hand tools, machinery, machine tools, etc. MAGNESIUM CASTINGS & PRODUCTS, LIMITED, 77/78, Buckingham Avenue, Trading Estate, Slough, Bucks.

Pig-Iron Merchants' Association

The twelfth annual general meeting of the Pig-iron Merchants' Association was held in the Queen's Hotel, Birmingham, on April 17. Before the meeting, the members had lunched together under the chairmanship of Mr. Arnold Carr (Thos. W. Ward, Limited, Sheffield). The principal guests were: Sir Walter St. D. Jenkins, independent chairman of the National Federation of Iron and Steel Merchants; and Mr. H. H. Berresford, chairman of the Foundry Pig-iron Producers' Association. In reply to the toast of the guests, Mr. Berresford made a happy speech on the relationship between the merchants and the makers.

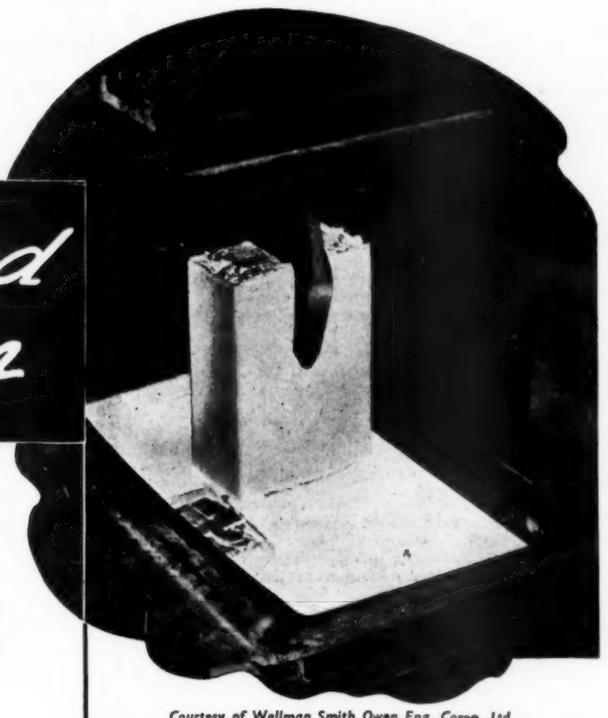
At the annual meeting, Sir Walter Jenkins spoke of the work done by the National Federation of Iron and Steel Merchants and the I.D.A.C. with reference to the merchants' function in industry. The meeting re-elected Mr. Arnold Carr as chairman, and the following other officers: Vice-chairman: Mr. H. Basil Darby; treasurer: Mr. C. A. Carson; committee: Messrs. A. E. Bond, C. Fanshawe, C. V. Fitton, William James, A. P. C. Pevington, E. Martin Smeeth, and A. Spargo. The chairman and Mr. A. E. Bond were elected the Association's representatives on the National Federation Council.

IN HEARTHS OF RE-HEATING AND FORGE FURNACES, SOAKING PITS, etc. . . . .

Uninterrupted Production

follows use of

PLASTIC K-N



Courtesy of Wellman Smith Owen Eng. Corpn. Ltd.

THE elimination of joints, a refractory surface possessing non-shattering properties able to withstand mechanical impact and abrasion without rupture or disintegration, a furnace bottom chemically neutral in its resistance to slag, whether acid or basic, and a high degree of refractoriness. These are some of the advantages which follow the use of Plastic K-N. An improved chromite composition, Plastic K-N when rammed into position forms a strong and durable hearth. Its unique slag and shock resisting properties ensure uninterrupted production, as well as cleaner ingots, forgings, sheets or plates.

Full details are available on request.

Some advantages obtained by use of Plastic K-N

FORGE & RE-HEATING FURNACES (Hearth)
Resists slag action, holds heat and promotes uniform heating of stock. Withstands severe abrasion and mechanical shock. Eliminates "pick up" from refractory materials.

SOAKING PITS (Hearth and Bridge Walls)
Slag and abrasion resisting surface together with non-shattering properties.

ELECTRIC BASIC FURNACES (Sub-Hearth)
Under dolomite or magnesite hearth; minimises possibility of a break-through.

WATER TUBE BOILERS (Black Liquor Fired)
As a refractory fill between tubes of water walls, also for hearths and coping of bridge walls. Resists the corrosive action of liquor and gases.

GENERAL REFRACTORIES LTD.

HEAD OFFICE: GENEFAX HOUSE, SHEFFIELD, 10. TELEPHONE 31113 (6 LINES)

G.P.18.

FIREBRICKS: *Glenboig Special, Glenboig Special Crown, Glenboig, Glenboig Crown, Castlecary, Dykehead, Gem, White Carr, Stour, Hycone, Alumantine, Hysilyn, Adamantine, Llangennech.*
BASIC BRICKS: *Spinella, Saxpyre, Supermag, Diazite, Dolomax.*
ACID-PROOF REFRACTORIES: *Obsidianite, Losol.*

INSULATION: *Amberlite* Bricks, Cement and Concrete.
SILICA BRICKS: *Lowood, Meltham, Allen, Quartex*
CEMENTS: *Sintex, Durax, Pyrolyte.* PLASTICS: *Durax, Rotaline. Plastic K-N., Glendoline, Ground Ganister, Steel Moulders' Compositions.* SILLIMANITE: Tank Blocks, Bricks and Cements. SANDS: Moulding, Brick Facing, Silica, Glass.

Raw Material Markets

Although various measures of economy have been introduced in the use of iron and steel of descriptions required in the production of war materials, consumption continues to expand as additional Government orders are placed. Only in exceptional cases are purchases sanctioned for other than first-priority business, and there will be no relaxation in the present policy of distribution during the period of hostilities. The Control are keeping imports down to the lowest practicable level. Even grades of iron and steel which are not required for the prosecution of the war effort are unobtainable except under licence.

Pig-Iron

MIDDLESBROUGH—Foundries associated with heavy engineering and shipbuilding are as busy as the capacity of their plant will allow, and replacement orders are coming to hand freely. Deliveries of pig-iron, fortunately, are keeping pace with the ever-increasing demands of these establishments. This is particularly gratifying, as foundry iron for users on the North-East Coast now has to be purchased in the Midlands, ironmakers in the Cleveland district being engaged on the production of iron for use in the steelworks. Occasionally a small tonnage of Cleveland foundry iron becomes available, but the quantity is negligible in comparison with the current rate of consumption. The position of the light-castings trade is slow to improve, but, on the whole, works in this section are rather busier than they were.

A very strong tone continues to rule in the hematite market, and local output is insufficient to cope with all demands, thus necessitating the use of a certain amount of American iron. Many consumers have been able to restrict their consumption by the incorporation of other grades of iron in their mixtures. Hematite users are offered little opportunity to cover themselves against future needs, business being transacted on a hand-to-mouth basis.

LANCASHIRE—Demand for iron from jobbing and light-castings foundries has shown some contraction of late, as the majority of these concerns continue to experience difficulty in procuring adequate business to maintain full-scale operations of their plants. In some respects, the easing of the demand from these sources has helped to promote better deliveries to other sections engaged on important contracts, such as heavy electrical engineers, machine-tool makers, and various branches of speciality engineering. Activity among these works is great and full-time operations are assured over a long period.

MIDLANDS—Supplies of high-phosphorus iron continue to arrive at receiving points regularly and, in fact, many users have useful reserve stocks on hand. This iron is largely used by manufacturers of light castings, although heavy engineers have lately been incorporating it in their mixtures, owing to the desirability of conserving supplies of better quality material. The normal trade of the light-castings industry remains difficult, and the amount of Government work placed in this branch is still much below that required to counteract the falling off of the usual outlets. Consequently, consumption of foundry iron is comparatively small, although the demand for high-phosphorus iron from the heavy engineering section involves quite considerable tonnages. The main requirements of the latter, however, are low-phosphorus and hematite irons, produced from imported ores, and the supply situation of these descriptions is less satisfactory. Urgent needs are being promptly met and every encouragement is given to consumers to utilise refined irons and iron and steel scrap in addition to high-phosphorus iron.

SCOTLAND—Reports from the Falkirk district indicate variable conditions among the makers of light castings. Some works are unable to maintain continuous operations, but those fortunate enough to secure contracts for Government departments are naturally busier. Satisfactory deliveries of foundry iron are forthcoming from the English Midlands. The position of the heavy ironfoundries remains very strong, and large quantities of iron are being called for by these concerns. Deliveries at times fall short of the desired level, but, on the whole, little inconvenience is experienced. It is necessary to supplement the outputs of both basic and hematite irons with foreign material.

Coke

The foundry coke trade is expected to remain active throughout the summer months, as it is certain that ironfounders will wish to build up substantial reserves before the winter. Many already have useful tonnages on hand, while the ovens, too, are generally able to deliver promptly from stock. For delivery to Birmingham and Black Country stations, the current price of Durham best foundry coke is 61s. 6d. per ton.

Steel

Practically all descriptions of steel are in heavy demand on Government account, and structural material, which lately has been rather quieter, appears to be becoming more active again. Outputs of all qualities are at peak levels, but the industry is not self-supporting, and it remains part of the work of the Control authorities to bring into the country supplies from abroad, chiefly from the United States in the form of finished products. Foreign purchases are, however, being confined to bare essentials, this being made possible by strict conditions governing distribution which ensure that licences are granted only to the most vital consumers. Full outputs of special qualities of steel are being taken up for the manufacture of munitions and aircraft, and larger tonnages could be readily absorbed.

Scrap

Deliveries of iron and steel scrap metal to the more important users appear to have improved, although the margin between home supply and demand remains too wide, with little prospect of any early change in the situation. Steelworks' demands are insatiable, while ironfoundries, too, are big consumers. Consumption of scrap has increased owing to the wider use of old metal in furnace mixtures, but if this commendable emergency measure is to be maintained at the present level—and, indeed, further developed, as it should be—much larger supplies of scrap will have to be collected.

Metals

Copper—While prompt delivery is being given of metal designed for use in the war machine, other consumers are not receiving anything like their normal tonnages. In view of the increasing use of copper for Government contracts, non-essential buyers are unlikely to be given much attention in the future. The supply situation in the United States appears to be rather less satisfactory than had earlier been thought to be the case, and it is now suggested that the stocks laid down by the Metals Reserve Company are inadequate. This may be the case, but, with large tonnages of South American metal available to supplement the heavy domestic output, it is unlikely that any acute shortage will be felt on the other side of the Atlantic.

Tin—The London tin market has been rather quieter during the past few days, while the heavy American purchases of the past few weeks have abated, presumably due to a lessening of tension in the Far East.

A recent report by C. S. Trench & Company, Inc., of New York, states that although the present position with respect to tin in the United States is more comfortable than that of any of the other strategic materials, whether of foreign or domestic origin, the conservation department of the Office of Production Management is proceeding with its plans to effect savings of, and substitutes for, tin. A meeting of the tin-can manufacturers was held in Washington on April 16 to consider reduction in the non-essential uses of tin-can containers in addition to reducing the tin-coating on tinplate between 10 per cent. and 25 per cent. from the present weight of a little over 1 to 1¼ lbs. of tin per 100 lbs. of tinplate. It is calculated that present stocks of primary pig-tin in the United States, plus shipments en route to that country, would satisfy normal requirements, without resort to restrictions, for at least 16 months. Messrs. Trench point out that Malaya, which used to be considered about the most reliable source of supply, has met its quota only in two months out of the eight months ending February and, whereas during this period it was permitted to export 67,025 tons, it actually exported only 55,563 tons. Since the 130 per cent. quotas came into effect, Malaya has exported at the rate of 83,300 tons per annum, as against 100,500 tons permitted.

Tin prices on the London Metal Exchange during the past week have been as follow:—

Cash—Thursday, £271 5s. to £271 10s.; Friday, £271 15s. to £272; Monday, £270 10s. to £270 15s.; Tuesday, £269 5s. to £269 10s.; Wednesday, £269 5s. to £269 10s.

Three Months—Thursday, £267 to £267 5s.; Friday, £267 to £267 5s.; Monday, £266 5s. to £266 10s.; Tuesday, £265 15s. to £266; Wednesday, £266 15s. to £267.

Spelter—While distribution of this metal is very carefully controlled, there appears to be no shortage of spelter where contracts associated with the war effort are concerned. Very large tonnages are being absorbed in this way, the brass diecasting and galvanising trades being well to the fore.

Lead—Supplies of lead are still more easily procured than other non-ferrous metals, and the authorities are not permitting this satisfactory state of affairs to deteriorate through the reckless use of the metal for unimportant purposes; fresh purchases of lead are subject to licence regulations, as is the case with other metals.

Patent Specifications Accepted

The following list of Patent Specifications accepted has been taken from the "Official Journal (Patents)." Printed copies of the full Specifications are obtainable from the Patent Office, 25, Southampton Buildings, London, W.C.2, price 1s. each. The numbers given are those under which the Specifications will be printed and abridged, and all subsequent proceedings will be taken.

530,041 BERGSMAN, E. B., ERIKSON, P.A.E.T. FREY, G. S., and HILDEBRAND, G. E. H. Electrolytic polishing of metals.

530,078 SOC. ITALIANA AEROPLANI IDROVOLANTI SAVOIA-MARCHETTI. High-resistance steel.

530,112 HALL, H. C. Chill moulds and dies.

530,213 HOLZWARTH-GASTURBINEN AKT.-GES. Arrangement for reducing heat strains and temperature stresses in the edge and corner-pieces of cast machine parts.

530,348 AUSTIN MOTOR COMPANY, LIMITED, DOLBY, F. C., and CRAMP, S. G. Means for use in longitudinal bending of lengths of metal.

530,377 DEMAG AKT.-GES. Blast furnaces.

530,741 ELECTRIC RESISTANCE FURNACE COMPANY, LIMITED, and MILLAR, W. J. Heat-treatment of metals.

530,853 AVERY, LIMITED, W. & T. (Schenck Eisengiesserei und Maschinenfabrik Darmstadt Ges., C.). Fatigue-testing machines.

530,890 WERF CONRAD N.V., and SCHOUTEN, C. Jigs for treating ore-bearing and like materials.

530,894 STEIN & ATKINSON, LIMITED, and BOOTH, T. A. Furnaces.

530,912 NAGY, A. Bearings for scientific, measuring, and other precision instruments, and other machine or tool parts from which great hardness and wear-resistance is required.

530,953 STEVENS, A. H. (Wellman Company, S. K.). Heat-treating furnaces.

530,995-6 JONES, W. D. Manufacture of metal articles or masses.

531,012 MCKEAN, J. G., and JONES, R. F. Core-drying ovens and the like.

531,016 LANCASHIRE & CORBY STEEL MANUFACTURING COMPANY, LIMITED, and ROSS, D. M. Method and means for use in the cold-rolling of metals.

531,017 JOHNSON & NEPHEW, LIMITED, R., ROBINSON, W., and TILGHMAN'S PATENT SAND BLAST COMPANY, LIMITED. Manufacture of wire.